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Foraging frequency and pattern of movement of different *Apis* species on parental lines of *Brassica napus* L.

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ABSTRACT: Study conducted on number of flowers visited/min and pattern of movement of different *Apis* species on parental lines of *Brassica napus* to evaluate their pollination efficiency, revealed that various bee species according to their foraging rate were: *A. cerana* = *A. mellifera* > *A. dorsata* > *A. florea*. Foraging frequency of *Apis* species was found to be maximum at 1200 h, followed by 1000, 1400 and 1600 hours. Number of flowers visited/min by all the species of honeybees was significantly more on cytoplasmically male sterile line as compared to that on restorer line. The effective intersexual flower visits (visits from R to CMS lines) of bees were extremely low (3.300–3.800%) which could not be considered satisfactory for hybrid seed production. All the four bee species showed very high percentage of intrasexual flower visits, however these bee species did not differ significantly for all types of intersexual and intrasexual flower visits. Bees tend to remain on the same parental line on which they started foraging, thus indicating higher floral constancy in their foraging behaviour. Effective visits were slightly more in 2:4 row ratio plots followed by 1:4 and 1:8 row ratios. © 2008 Association for Advancement of Entomology

KEYWORDS: *Apis cerana*, *Apis dorsata*, *Apis florea*, *Apis mellifera*, *Brassica napus*, *pollination efficiency*, *hybrid seed production*

INTRODUCTION

Honeybees are the most efficient and abundant amongst insect pollinators of *Brassica* Crops. In general, foraging rate (number of flowers visited/min) and pattern of movement of different bee species on parental lines of *B. napus* determine their pollination efficiency. More the foraging rate of a bee, more are the chances of pollination. Foraging rate of any insect visitor depends on many factors like instinctive foraging behaviour, length of proboscis (Inouye, 1980), floral structure (Free, 1970), particularly the corolla depth (Gilbert, 1980), type and quantity of floral rewards (Rao and Suryanarayana, 1990; Rao, 1991; Dashad *et al.*, 1992). On small sized flowers

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foraging speed of bees is faster (Mohr and Jay, 1988). Hours of day also affect the foraging frequency of insects.

Honeybees being potential agents of pollen transfer are effectively used for pollination and production of hybrid seeds. The flowers on cytoplasmically male sterile (cms) line must be visited by nector seeking pollen coated insects that have earlier visited the flowers of restorer (R) line during the same visit. Intersexual flower visits of honeybees may not take place to a desired extent because flowers of both the parental lines are not equally attractive to them and they show higher degree of floral constancy.

Present study is an attempt to compare foraging rates of different *Apis* species and their pattern of movement between R and CMS lines in hybrid seed production plots of *B. napus* to assess their pollinating efficiency.

MATERIALS AND METHODS

Experimental plots for hybrid seed production were raised under Punjab conditions by sowing seeds of cytoplasmically male sterile (CMS) line (TCMS-PR-05) and restorer (R) line (TFR-91) of *B. napus* hybrid PGSH-51, by following recommendations of Punjab Agricultural University, Ludhiana (Punjab) during years 2003–2004 and 2004–2005. Selected male to female row ratios were 2:4, 1:4 and 1:8, the recommended ratio being 2:4. Early flowering R line plants were detopped to make the flowering of two lines synchronous. Two colonies each of *A. mellifera*, *A. cerana*, and *A. florea* (by comb transfer technique) were placed in the field. *A. dorsata* hives were present in nearby trees. Observations in each experiment were taken at 1000, 1200, 1400 and 1600 hours. Following two experiments were conducted.

For foraging frequency assessment of *Apis* species on parental lines of *B. napus* the number of flowers visited/min by a particular bee species on male and female lines, was counted with help of stop clock at selected hours during day. This experiment was conducted on 20 alternating days in full blooming season of crop during year 2004 and 2005. The pooled mean of two observations has been considered.

Pattern of movement of *Apis* species between parental lines of *B. napus* was studied in plots of various row ratios by following a particular bee for one minute at selected timing of the day and the percentage of male to female, male to male, female to female and female to male visits were recorded. Observations were started from male and female rows alternatingly and recorded separately. This experiment was conducted for 20 alternating days in full flowering season of crop during year 2005.

Data collected from above two experiments were consolidated, tabulated, transformed ($\sqrt{x} + 1$ transformations and arc sin transformations in experiment no. 1 and 2 respectively) and subjected to analysis of variance. Significance was tested at 5 per cent level.

RESULTS AND DISCUSSION

Foraging rates of different honeybee species at the selected hours of day on R and CMS lines are shown in Table 1A. On the basis of mean number of flowers visited/min (Table 1B) various bee species can be arranged as: *A. cerana* (19.143 flowers/min) = *A. mellifera* (18.836 flowers/min) > *A. dorsata* (14.460 flowers/min) > *A. florea* (7.623 flowers/min). The results of this study are in line with the observations recorded by Desh Raj and Rana (1994) who found that foraging speed of *A. cerana* was non significantly more than that of *A. mellifera* on rapeseed (*B. campestris var.* brown sarson) bloom. Observations were recorded on foraging speed of these two bee species on apple bloom (Verma and Dulta, 1986) and on plum flowers (Rana, 1989). Jhajj *et al.* (1996) found the foraging speed of bee species as: *A. mellifera* > *A. dorsata* > *A. florea* on raya and brown sarson.

Various day hours according to foraging rate of *Apis* species (Table 1C) could be arranged as: 1200 h (16.359 flowers/min) > 1000 h (15.166 flowers/min) > 1400 h (14.792 flowers/min) > 1600 h (13.744 flowers/min). Highest foraging rate was observed at 1200–1300 hours on *Brassica* crops by many workers (Dhaliwal and Bhalla, 1980; Desh Raj and Rana, 1994; Anonymous, 1999). Comparatively more foraging rate of honeybees at 1200 h might be due to the availability of floral rewards declined by this time due to increased foraging activity of bees as observed by Meyerhoff (1954) in case of swede rape. So, less time was needed to take forage from a flower and more number of flowers were visited by a bee to collect a required load of pollen or nectar. Hours of the day played an important role in regulating foraging rate of bees.

Data of present study (Table 1D) showed that average foraging rates of bees (Irrespective of bee species and day hours) was significantly higher on CMS line (16.647 flowers/min) than that on R line (13.384 flowers/min). These results are similar to those of Dashad *et al.* (1992), who observed that foraging rates of insect visitors were different on different cultivars of apple. Difference in foraging rates of *Apis* species on R and CMS lines may be due to the difference in shape and size of flowers, expansion of their petals, type and quantity of floral rewards (Rao and Suryanarayana, 1990; Rao, 1991; Dashad *et al.*, 1992) and some other morphological and physiological traits of flowers of two lines. The R line flowers offer both nectar and pollen, hence the bees visiting them were pollen and/or nectar gatherers. They spent longer time on individual flower and thus have lower foraging rate. While flowers of CMS line offer only the nectar as they do not produce pollen, the foraging bees were only nectar gatherers. Therefore, honeybees spent less time on CMS line flowers and have higher foraging rate. Adegas and Nogueira (1992) also observed that nectar collecting bees spent less time per flower compared to pollen gatherers on *B. napus* L. var *oleifera* (cultivar CTC-4).

Data in Table 2, 3 showed that in plots of all the row ratios, either the observations were started from male or female line, intersexual flower movement, especially male to female flower visits of bees (effective for cross pollination) were extremely low. Comparatively more of such movements were recorded in case of *A. florea* (1.375–

TABLE 1A. Mean number of flowers visited/min by different *Apis* species on parental lines of *B. napus* at selected hours of day

Day hours	*Apis species*	Number of flowers visited/min.	
		R line	CMS Line
1000 h.	*A. mellifera*	16.583	20.644
		(4.1860)	(4.6520)
	A. cerana	18.063	20.428
		(4.3589)	(4.6273)
	A. dorsata	12.416	16.750
		(3.6618)	(4.2130)
	A. florea	7.000	9.442
		(2.8262)	(3.2297)
1200 h.	*A. mellifera*	18.756	23.146
		(4.4377)	(4.9102)
	A. cerana	18.146	23.213
		(4.3668)	(4.9167)
	A. dorsata	14.338	16.354
		(3.9156)	(4.1501)
	A. florea	7.400	9.519
		(2.8917)	(3.2413)
1400 h.	*A. mellifera*	16.190	19.906
		(4.1411)	(4.5578)
	A. cerana	16.250	22.575
		(4.1532)	(4.8413)
	A. dorsata	13.693	14.500
		(3.8300)	(3.9361)
	A. florea	5.814	9.406
		(2.6083)	(3.2122)
1600 h.	*A. mellifera*	16.022	19.438
		(4.1256)	(4.5203)
	A. cerana	15.250	19.219
		(4.0304)	(4.4893)
	A. dorsata	13.750	13.875
		(3.8398)	(3.8559)
	A. florea	4.464	7.938
		(2.3372)	(2.9833)

TABLE 1B. Foraging rates of different *Apis* species irrespective of day hours and parental lines

Apis species	*A. mellifera*	*A. cerana*	*A. dorsata*	*A. florea*
Number of flowers visited/min.	18.836 (4.4413)	19.143 (4.4730)	14.460 (3.9253)	7.623 (2.9162)

TABLE 1C. Foraging rates of *Apis* species at different day hours, irrespective of bee species and parental lines

Day hour	1000 h	1200 h	1400 h	1600 h
Number of flowers visited/min.	15.166 (3.9694)	16.359 (4.1037)	14.792 (3.9100)	13.744 (3.7727)

TABLE 1D. Foraging rates of *Apis* species on R and CMS rows irrespective of bee species and day hours

Parental line	R Line	CMS Line
Number of flower visited/min.	13.384 (3.7319)	16.647 (4.1460)

CD0.05
For day hours 0.102
For *Apis* spp. 0.102
For Parental lines 0.072
For interaction day hours x *Apis* spp. Non significant
For interaction day hours x Parental lines Non Significant
For interaction *Apis* spp. X Parental lines 0.145
For interaction day hours x *Apis* spp. X Parental line. Non significant.
Figures in parentheses are $\sqrt{n} + 1$ transformations.

3.375%), followed by *A. mellifera* (0.775–2.700%) and *A. cerana* (0.425–1.105%). Minimum percentage of such visits was recorded in case of *A. dorsata* (0.300–0.962%). However all the bee species did not differ significantly for different types of inter-sexual or intra-sexual flower visits. Comparatively more percentage of male to female flower visits of *A. florea* bees may be due to fact that this bee species is a dominant nectar gatherer and both male and female lines provide nectar. More nectar gathering behaviour of *A. florea* was observed by Panda *et al.* (1995) on niger bloom.

Intra-sexual flower visits were much higher than inter-sexual flower visits in case of all species of *Apis*. When observations were started from male line (Table 2, the male to male flower visits were dominant (76.900–95.475%) followed by female to female (3.062–18.970%) Similarly, when observations were started from female line (Table 3, the female to female flower visits were maximum (69.075–93.308%) followed by male to male visits (5.245–23.750%). In both the conditions , inter-sexual flower movement was very low with a range of 0.300–3.800. Bees tried to remain on same parental line on which they started foraging, indicating thereby, a clear cut floral constancy in their foraging behaviour. A minor percentage of bees showed crossing over between male and female lines bring about low degree of cross pollination. Similar type of results regarding low percentage of inter-sexual flower visits and higher percentage of intra-sexual flower movement of *A. mellifera* in hybrid seed production plots of B. *napus* have also been reported earlier (Anonymous, 1999). Honeybees tend to visit within an inbred rather than between lines (Johnson, 1972). Faulkner (1974) also observed

TABLE 2. Movement of *Apis* species between male and female lines of *B. napus* (while starting observation from male row)

Male to female Row ratio	Percentage of various types of visits of *Apis* species between male and female rows				
	Apis species	M-F	M-M	F-F	F-M
2:4	*A. mellifera*	1.347	92.435	5.010	1.208
		(6.432)	(74.276)	(12.785)	(6.112)
	A. cerana	0.862	93.975	4.300	0.863
		(5.108)	(75.902)	(11.905)	(5.108)
	A. dorsata	0.738	95.475	3.062	0.725
		(4.537)	(78.000)	(9.951)	(4.504)
	A. florea	2.995	80.880	13.000	3.125
		(9.821)	(64.118)	(21.107)	(10.011)
	Average	1.486	90.691	6.343	1.480
		(6.474)	(73.074)	(13.937)	(6.434)
	CD 0.05 for *Apis* spp. Non significant for movement 1.527 For interaction *Apis* spp. x movements = 3.054				
1:4	*A. mellifera*	1.050	87.237	10.825	0.888
		(5.700)	(69.177)	(19.144)	(5.035)
	A. cerana	0.525	90.127	8.898	0.450
		(4.141)	(71.819)	(17.212)	(3.840)
	A. dorsata	0.523	91.282	7.692	0.500
		(3.882)	(73.006)	(15.973)	(3.804)
	A. florea	2.350	76.900	18.375	2.375
		(8.660)	(61.320)	(25.360)	(8.703)
	Average	1.112	86.386	11.448	1.053
		(5.596)	(68.830)	(19.422)	(5.346)
	CD 0.05 for *Apis* species Non significant for *movements* 1.490 for interaction *Apis* spp x movements 2.980				
1:8	*A. mellifera*	0.775	79.455	18.970	0.688
		(4.876)	(63.102)	(25.780)	(4.616)
	A. cerana	0.425	85.975	13.150	0.450
		(3.719)	(68.192)	(21.073)	(3.816)
	A. dorsata	0.400	86.722	12.578	0.300
		(3.390)	(68.696)	(20.725)	(2.933)
	A. florea	1.375	87.825	9.550	1.250
		(6.661)	(69.616)	(17.978)	(6.337)
	Average	0.744	84.994	13.562	0.672
		(4.662)	(67.401)	(21.389)	(4.426)
	CD 0.05 for *Apis* spp-non significant for *movements* 1.363 for interaction *Apis* spp. x movements 2.727				

Figures in parentheses are arc sine transformations.

TABLE 3. Movement of *Apis* species between male and female lines of *B. napus* (while starting observations from female row)

Male to female row ratio	Percentage of various types of visits of *Apis* between male female rows				
	Apis species	M-F	M-M	F-F	F-M
2:4	*A. mellifera*	2.700	10.608	83.467	3.225
		(9.170)	(18.748)	(66.348)	(9.969)
	A. cerana	1.105	13.970	83.600	1.325
		(5.930)	(21.805)	(66.278)	(6.459)
	A. dorsata	0.962	12.072	85.965	1.000
		(5.328)	(20.249)	(68.116)	(5.438)
	A. florea	3.375	23.750	69.075	3.800
		(10.452)	(29.154)	(56.222.)	(11.156)
	Average	2.036	15.100	80.527	2.338
		(7.720)	(22.489)	(64.241)	(8.255)
	CD 0.05 for *Apis* spp. non significant				
	for movements 1.968				
	for interaction A*pis* spp. x movements 3.936				
1:4	*A. mellifera*	2.060	8.538	86.917	2.458
		(7.946)	(16.805)	(69.071)	(8.676)
	A. cerana	1.060	9.590	88.100	1.250
		(5.896)	(17.872)	(69.957)	(6.391)
	A. dorsata	0.700	7.450	90.950	0.900
		(4.594)	(15.749)	(72.641)	(5.217)
	A. florea	2.900	19.900	74.225	2.975
		(9.671)	(26.470)	(59.509)	(9.803)
	Average	1.680	11.370	85.048	1.902
		(7.027)	(19.224)	(67.795)	(7.522)
	CD 0.05 for *Apis* spp. non significant				
	for movements 1.728				
	for interaction *Apis* spp. x movements 3.456				
1:8	*A. mellifera*	1.525	7.218	89.782	1.475
		(6.843)	(15.267)	(71.694)	(6.730)
	A. cerana	0.925	5.245	92.855	0.975
		(5.456)	(13.052)	(74.682)	(5.593)
	A. dorsata	0.300	6.167	93.308	0.225
		(3.037)	(14.257)	(75.141)	(2.641)
	A. florea	1.600	8.525	88.275	1.600
		(7.204)	(16.957)	(70.013)	(7.204)
	Average	1.088	6.789	91.055	1.069
		(5.635)	(14.883)	(72.833)	(5.542)
	CD 0.05 for *Apis* spp. non significant				
	for movements 1.596				
	for interaction *Apis* spp. x movements 3.193				

that a mean ratio of 30:1 was present between visits of bees to flowers on the same inbred and those flowers on different inbreds in case of cauliflowers while such ratio was recorded to be 33:1 in case of Brussels sprout (Faulkner, 1976). Similar type of conclusions were drawn regarding effective bee visits in hybrid seed production plots of Brussels sprout (Free and Williams, 1983) and cotton (Eisikowitch and Loper, 1984).

Low percentage of inter-sexual flower visits was due to the fact that male flowers of *B. napus* were more attractive to bees as compared to the CMS flowers due to their larger size, better looks and availability of both pollen and nectar. Since there is no pollen for bees to collect from male sterile flowers, they visit the flowers to collect nectar only. Flowers of CMS line compete poorly for attention of pollinators. More attractiveness of male line flowers of *B. napus* has also been confirmed by many workers (Mesquida and Renard, 1979a; Ohsawa and Nawal, 1988; Anonymous, 1999). Difference in morphology, physiology, floral rewards, foraging cues, floral events, aroma chemistry etc of male and female flowers causes selective foraging by honey bees in case of B. napus (Renard and Mesquida, 1987; Mosquida *et al.*, 1987; Ohsawa and Nawal, 1988; Anonymous, 1999).

Minor increase in intersexual flower visits of bees was found with changing row ratios from 1:8, through 1:4 to 2:4, either observations were started from male or female line. This is due to the fact that frequency of male rows was higher in case of 2:4 row ratio which is recommended ratio, followed by 1:4 and 1:8 planting ratio.

Any species of *Apis* which has higher foraging rate is considered to be an efficient pollinator as it may pollinate more number of flower/min. Thus *A. cerana* and *A. mellifera* were found better pollinators and they were followed by *A. dorsata* and *A. florea*. Hours of the day also played an important role and maximum foraging rate was recorded at 1200 h. Significantly more number of flowers were visited/min by bees on CMS line as compared to that on R line.

Effective intersexual flower visits (movement from male to female line) of all the four *Apis* species were low and could not be regarded as satisfactory for hybrid seed production. Therefore research should be oriented to select/breed lines which are equally attractive to honeybees, have synchronized flowering and provide floral rewards of equal value. Essential factors for bee attractiveness should be studied and incorporated into new hybrid system. Recommended planting ratio of 2:4 was found suitable as far as pollination causing visits were concerned.

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Time of adult emergence and sex ratio of rice blue beetle, *Leptispa pygamaea* Baly (Coleoptera: Chrysomelidae) and extent of damage caused by the pest to two rice varieties

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ABSTRACT: The adult emergence and sex ratio of rice blue beetle, *Leptispa pygmaea* Baly was studied at Pattambi, Kerala during *Kharif* 2004–*Rabi* 2005. Highest emergence occurred between 8.00 and 11.00 h (25 and 15 per cent) and between 16.00 to 18.00 h (20 and 10 per cent). The female to male ratio during the peak period, June to November, in the field was 2.6:1. But during the lean period, the male beetles were more dominant in the field. Though both grubs and adults caused damage to rice; highest damage was inflicted by the grub followed by the adult female and male beetles irrespective of rice varieties. A grub consumed 82 per cent more leaf area than a male beetle while a female beetle consumed 33 per cent more leaf area than a male. The rice variety Jyothi was more susceptible than Aiswarya to the attack of *L.pygmaea*. © 2008 Association for Advancement of Entomology

KEYWORDS: rice blue beetle, *Leptispa pygmaea*, time of adult emergence, sex ratio, damage intensity

INTRODUCTION

Severe outbreaks of rice blue beetle, *Leptispa pygmaea* Baly have been reported recently in the major rice growing tracts of northern districts in Kerala. The pest inflicted extensive damage during the early stages of rice in both *Kharif* and *Rabi* seasons. Since the blue beetle has so far been considered as a minor pest, no study on this pest has been carried out in Kerala. A study on the time of emergence and sex ratio of the pest and the nature and extent of damage caused would be helpful in deciding control strategies. Hence, the present study on these aspects was undertaken.

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MATERIALS AND METHODS

The experiment was carried out in the net house under prevailing temperature (maximum 30.1 ± 1.4 °C; minimum 23.1 ± 0.69 °C) and relative humidity (94.33 ± 2.11%) at the Regional Agricultural Research Station, Pattambi, Kerala Agricultural University during 2004–2005. For assessing the time of emergence of *L. pygmaea*, 15 days old potted rice seedlings (variety Jyothi) with 30 freshly pupated pupae of rice blue beetle each were collected from the field and were covered with polyester cage and kept in the net house. Three replications were maintained for each treatment with a total of 90 pupae. The emergence of adult beetle was observed at one hour interval between 0800 to 1800 h for a period of 3–4 days. The mean per cent emergence of adult beetles was worked out separately for each replication. For studying the sex ratio, male and female beetles were collected randomly by 10 net sweeps from the rice fields at monthly interval during the peak period of beetle activity from June to November, 2005.

To assess the extent of damage caused by *L. pygmaea* on different varieties of rice, single adult (male/ female) and grub was released separately on 15 day old potted rice seedlings of Jyothi (short duration) and Aiswarya (medium duration) covered with polyester cages (49 cm × 18 cm). Four replications were maintained for each stage of the beetle. Number of damaged leaves per hill was recorded at 9 days after release. The leaf area consumed by the adult (male, female) beetle and grub was assessed by graphical method.

RESULTS AND DISCUSSION

The hourly emergence of *L.pygmaea* from 8.00 h to 18.00 h was 25.6, 20.0, 15.6, 5.6, 2.2, 0.0, 0.0, 7.8, 17.8 and 5.6 per cent (Table 1). Highest emergence of adult beetles (25.6 and 15.6 per cent) occurred between 08.00 and 11.00 h and thereafter, it was gradually reduced and reached 2.2 per cent between 12.00 and 13.00 h. There was no emergence during 13.00 to 15.00 h. The adults started emerging again from 15.00 h (7.8 per cent) and rose to 17.8 per cent between 16.00 and 17.00 h and ended with 5.6 per cent between 17.00 and 18.00 h. It is thus evident that the emergence of rice blue beetle was highest during morning and evening and no emergence occurred during the noon time when the temperature was at its peak indicating the influence of temperature on the adult emergence of rice blue beetle. The time of adult emergence has got much significance in chemical management of the pest as it would help in deciding the time of insecticide application preferably with the peak emergence of the beetle either in the morning or evening hours. No earlier work has been reported on the time of emergence of *L. pygmaea*. The present finding is in conformity with Swamiappan *et al.* (1990) who observed that the active mating of *L. pygmaea* occurred during morning and evening hours coinciding with the peak emergence of the adult beetles.

Adult beetle population recorded by monthly sweep net collections from the field during the peak period of activity from June'05 to November'05 were 185, 220, 211,

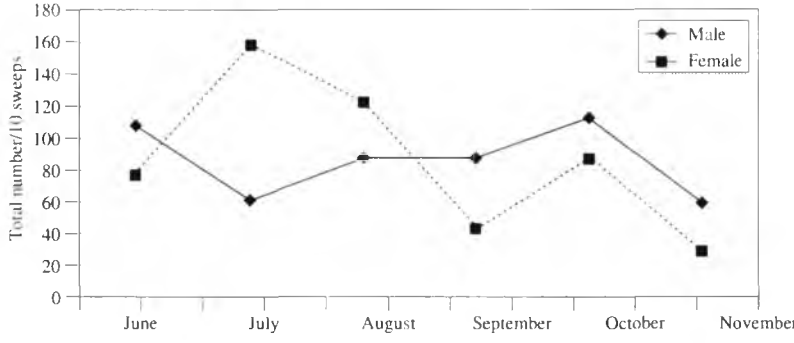

FIGURE 1. Average number of male and female beetles in the field (year 2005).

TABLE 1. Time of emergence of *L. pygmaea* during different hours of the day

Time (Hours)	Number of adult beetles emerged	
	Mean	Per cent emerged in each interval
8.00–9.00	7.7	25.6
9.00–10.00	6	20.0
10.00–11.00	4.7	15.6
11.00–12.00	1.7	5.6
12.00–13.00	0.7	2.2
13.00–14.00	0.0	0.0
14.00–15.00	0.0	0.0
15.00–16.00	2.3	7.8
16.00–17.00	5.3	17.8
17.00–18.00	1.7	5.6

132, 202 and 90. The number of male/female population in the above catches were 108/77, 61/159, 88/123, 88/44, 114/88 and 60/30 (figure 1). Females predominated the field population during July and August when the total population was high and males were dominant during June, September, October and November, 2005 when the total field population was comparatively lower. This is in close agreement with the results of Dalvi *et al.* (1985).

Both the grub and adult of *L. pygmaea* feed on the upper surface of rice leaves by scraping chlorophyll matter, leading to longitudinal white streaks on them. The streaks made by the grub were found to be shorter and narrower as earlier reported by Patel and Shah (1985). The damage of blue beetle resembled the attack of rice leaffolder, *Cnaphalocrocis medinalis* except for the absence of webbing of leaves. In case of severe damage by *L. pygmaea* the rice leaves were seen folded longitudinally and ultimately dried up. From a distance, the damaged rice patch showed severe drying. Swamiappan *et al.* (1990) also observed that in certain pockets, when the young rice

TABLE 2. Feeding intensity of *L. pygmaea* on rice varieties

Rice variety	Stage of the beetle	Leaf damage (%)	Leaf area consumption (mm^2)
Jyothi	Grub	67.09	3.82
	Adult female	28.27	1.04
	Adult male	13.65	0.70
Aiswarya	Grub	57.55	2.58
	Adult female	25.17	0.60
	Ault male	10.47	0.34

plants were attacked by rice blue beetle, it resulted in stunting and severe drying symptoms and the incidence was higher in shaded areas.

Among the different stages of the rice blue beetle, grub caused the highest damage followed by adult female in both the varieties of Jyothi and Aiswarya (Table 2). Male beetles caused lowest damage to rice leaves. Grubs caused 67.09 and 57.55 per cent while male beetles caused 13.65 and 10.47 per cent leaf damage in Jyothi and Aiswarya respectively. The grub stage was found to cause 16.6 per cent increase in damage in Jyothi over Aiswarya thus indicating a higher susceptibility of Jyothi to *L. pygmaea*. In Jyothi, grub caused 80 per cent more damage than male beetle while female beetle caused 52 per cent more damage than the male. But in Aiswarya, grub feeding was 82 per cent more than that of the adult male beetle whereas the female beetle caused 58 per cent more damage than the male.

The same trend was observed in leaf area consumption also by the different stages of *L. pygmaea*. Leaf area consumption was more in Jyothi than in Aiswarya (Table 2). The grub consumed highest leaf area of 3.82 mm^2 in Jyothi and 2.58 mm^2 in Aiswarya. Adult female beetle consumed leaf area of 0.6 mm^2 in Aiswarya and 1.04 mm^2 in Jyothi .The consumption of male beetle was 0.34 mm^2 and 0.70 mm^2 in Aiswarya and Jyothi respectively. The cumulative consumption due to grub, male and female beetle was 5.56 mm^2 leaf area in Jyothi and 3.52 mm^2 in Aiswarya again confirming the higher susceptibility of Jyothi to the pest. It is thus proved that grub of *L. pygmaea* caused the maximum damage followed by female and male adult beetles irrespective of varieties in rice. A grub consumed 82 and 87 per cent more in Jyothi and Aiswarya respectively than that consumed by a male beetle, while the female beetle consumed 32.6 and 43 per cent more leaf area than that by a male in Jyothi and Aiswarya. In rice hispa, similar observations were reported by Deka and Hazarika (1997) who indicated that significantly more leaf area was consumed by females than males. Budharaja *et al.* (1979) observed that a single adult beetle of rice hispa consumed 25.3 mm^2 leaf area.

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Histomorphological derangements in the ovary of *Oryctes rhinoceros* (Coleoptera: Scarabaeidae) treated with methanolic extract of *Annona squamosa* leaves

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ABSTRACT: Topical application of methanolic extract of *Annona squamosa* leaves caused histomorphological aberrations in the ovary of the adult *Oryctes rhinoceros* affecting full growth of ovum. © 2008 Association for Advancement of Entomology

KEYWORDS: *Oryctes rhinoceros*, *Annona squamosa*, effect of plant extract, ovary

INTRODUCTION

Phytochemicals are known to inhibit reproduction in various Orders of insects. Shalom *et al.* (1988) found abnormal oocyte development in *Locusta migratoria* by azadirachtin. *Acorus calamus* extracts resulted in decreased reproductive potential in *Tribolium castaneum* (Joseph *et al.*, 1994). Essential oils from the rhizomes of *Acorus calamus* were toxic to the eggs and induced significant reduction of oviposition in *Callosobruchus phaseoli* (Rahman and Schmidt, 1999). Limonoids from neem, *Azadirachta indica* and methanol extracts of leaves from the Indian white cedar *Dysoxylum malabaricum* showed anti ovipositional activity in *Anopheles stephensi* (Nathan *et al.*, 2005, 2006). The present study was undertaken to assess the effect of methanolic extract of the leaves of *Annona squamosa* (Annonaceae) on the ovary of the coconut rhinoceros beetle, *Oryctes rhinoceros*.

MATERIALS AND METHODS

Adults of *Oryctes rhinoceros* were obtained from late 3rd instar larvae collected from local dung pits and reared in the laboratory in sterilized cow dung. Adult eclosion date was noted to determine the age of the beetles. One day old beetles were used for the treatment. Experiment and control groups consisted of seven beetles each.

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The beetles were kept individually in glass containers with wide mouth. They were fed on ripe banana pieces and checked twice a day to monitor survival. Mature leaves of *A. squamosa* were dried under shade, powdered and extracted successively using methanol. After evaporation of the solvent, 0.1% stock solution of the solute was prepared, by dissolving 100 mg of it in 100 ml methanol. Using a Hamiltons microlitre syringe 10 μl of the stock solution (10 μg Annona extract) was topically applied, on the ventral side of the abdomen to see whether there is any direct effect on the ovaries. Controls received an equal volume of methanol. Treated and control insects were dissected in cold insect Ringer under binocular dissection microscope, on the 34th day as it was understood from preliminary studies that vitellogenesis and choriogenesis were completed at least in the proximal oocytes of all ovarioles by 32–34 days. Morphological observations were made in unfixed tissues under dissection microscope. Ovarioles were fixed in aqueous Bouins fixative for 48 h. Following standard histological procedures, paraffin sections, 5 μm thick, were stained in Ehrlich's Haematoxylin and Eosin, mounted in DPX and examined under the light microscope.

RESULTS AND DISCUSSION

Morphological variations were observed in the ovarioles of the treated beetles. In treated beetles, the terminal filaments are very much reduced or absent, and as a result the germaria floated free in the body cavity. In the control, terminal filaments are long and interconnected at their tips. Germarium in the treatment is short; not intact and is easily rupturing. The vitellarium is reduced, formed of 2 or 3 fragile follicles, while in the control there are 5–7 follicles in various stages of maturation; the proximal one being the most developed. In the treated beetles, the proximal and penultimate follicles show abnormal shape and look slightly compressed. Occasionally, the proximal and penultimate follicles appear fused. Anterior to the penultimate follicle, one more follicle is seen in some ovarioles. Follicles did not show inner, dark granules seen in the control. The interfollicular tissue which is distinct in the control, is indistinct in the treated beetles (figure 1a, b).

Ovarioles of the treated beetles also showed histological abnormalities. Germarium of control is almost uniformly quiescent and passive composed of trophocytes with indisinct cell boundaries. In the treated beetles, the germarium is degenerated; a major part of it is diffused and vacuolated. There are a few trophic nuclei in the diffused mass. Basal part of the germarium consists of prefollicular cells and a few pro oocytes in the controls, while in the treated lot, the prefollicular region is empty, vacuolated and distorted.

Vitellarium is highly abnormal in treated beetles, consisting of 3–4 abnormal shaped follicles looking as if some of them are fused. The interfollicular tissue is not differentiated. In all follicles, follicular epithelium is thin, disrupted and not properly oriented; follicle cells are deformed; vitellogenesis and choriogenesis are arrested (figure 2). Vitellarium of the control consists of 5–7 follicles of which the anterior one or two are in pre/early vitellogenesis and the remaining ones in progressive stages of

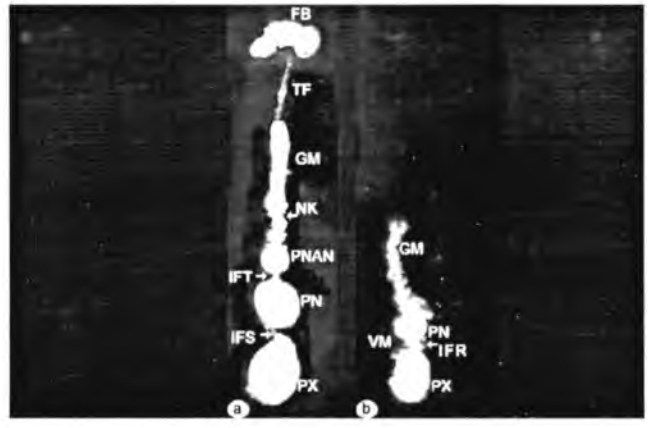

FIGURE 1. Morphology of ovariole (a) control (b) treated.

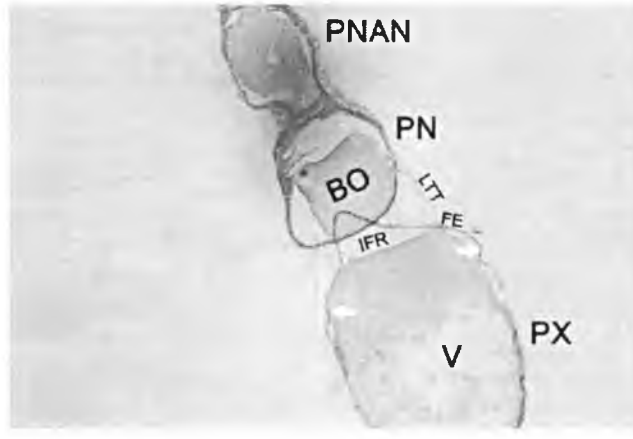

FIGURE 2. L.S. of the vitellarium of the treated beetle (× 100).

vitellogenesis. Each follicle is formed of an oocyte and a layer of follicular epithelium surrounding it. Follicular epithelial cells of the vitellogenic follicles are big, round and are actively engaged in the transfer of vitellogenic materials into the oocyte. The interfollicular tissue is formed of thin walled cells of varying shapes, generally round or spindle shaped. It is continuous with the follicular epithelium of the succeeding and preceding oocytes. On either side of the inter follicular tissue the inner layer of the ovariole sheath is expanded and modified into a trophic tissue, named in this study as the lateral trophic tissue (Fig.3). In the proximal oocyte of the control, vitellogenesis is completed and yolk is uniformly distributed in the form of globules of varying size and as fine granules. After the completion of vitellogenesis a chorion is deposited by the follicle cells. The proximal oocyte of treated beetles is almost flattened with irregular

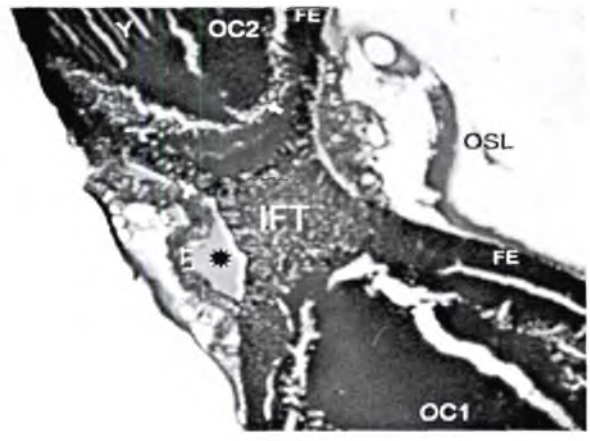

FIGURE 3. L.S. of vitellogenic follicle of control beetle (×200).

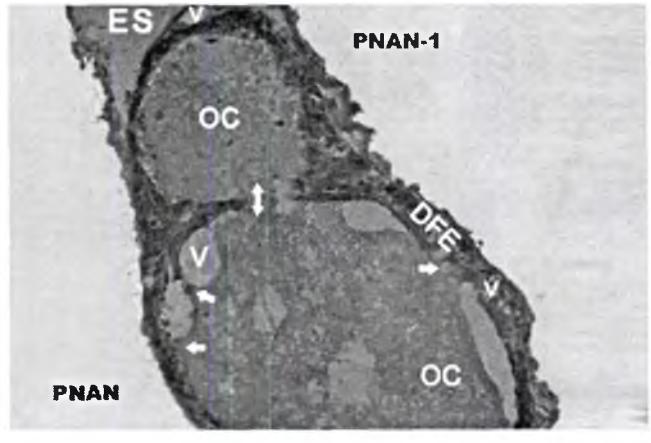

FIGURE 4. L.S. of vitellogenic follicle of treated beetle (×200).
TF, Terminal filament; GM, Germarium; VM, Vitellarium; IFS, Interfollicular stalk; IFT, Inter follicular tissue; IFR, Inter follicular region; FE, Follicular epithelium; PX, Proximal oocyte; PN, Penultimate; PNAN, Anterior penultimate; Y, Yolk; LTT, Lateral trophic; BO, Block of; DFE, Defective follicular epithelium; V, Vacuoles; FB, Fat body; ES, Empty space; OC1 & 2, Vitellogenic ic oocytes; OSL, Outer layer of ovariole sheath.
Arrows indicate transfer of vitellogenic materials from LTT, IFT and FE towards the oocytes in figure 3, and bulging of ooplasm in figures 2 and 4.
Double headed arrow indicates continuity of the ooplasm of the oocytes, IFT being absent.
Asterisk indicates secretions accumulated between LTT, IFT and FE.

borders and cytoplasmic protrusions. Ooplasm looks reticulate due to vacuolation and shrinkage. The follicular epithelium is thin and a major part of it is lifted off from the oocyte surface. The penultimate oocyte is compressed; ooplasm appears

as a single block and empty spaces are seen between the oocyte and the follicular epithelium. Cellular integrity of the follicular epithelium is not evident, but the layer holds some secretion which is in contact with the ooplasm. There is no interfollicular tissue between proximal and penultimate oocytes, the region being empty. The lateral trophic tissue is thin and membraneous (figure 2). Ooplasm of the follicles which are situated anterior to the penultimate one shows vacuolation and bulging towards the follicular epithelium. These oocytes are continuous since there is no inter follicular tissue in between. Empty spaces are seen in front of the follicles and also between the follicular epithelium and the oocyte (figure 4).

Morphological variations observed in the present study due to Annona leaf extract treatment includes: reduced size of ovarioles, reduced number of follicles and absence of inter follicular tissue. Ovariole size, length and oocyte number were reduced in *Dysdercus cingulatus* treated with *Eupatorium odoratum* and *Vitex negundo* extracts (Prameela, 1997). Reduced ovary size and oocyte growth were observed in *Ceratitis capitata* treated with *Annona squamosa* seed extract (Epino and Chang, 1993) and in neem fed females of *Epilachna varivestis* (Schulz, 1981). Ghazawi *et al.* (2007) reported shrinkage of ovaries, oocyte growth inhibition and reduced number of eggs in the grasshopper *Heteracris littoralis* treated topically with azadirachtin. Methanolic neem seed kernel extract inhibits ovary development and oocyte differentiation in *Trogoderma granarium* (Chellayan and Karnavar, 1990a). In the treated ovary of *O. rhinoceros* the terminal filaments are either very short and free or absent. Free and short terminal ends of ovarioles and reduced ovariole length were reported in *Corcyra cephalonica* emerged from neem fed larvae (Chanda and Chakravorty, 2000).

The extract induced high degenerative changes in the germarium involving vacuolation in the trophic and pre follicular regions. Presence of empty spaces and vacuolated cytoplasm might be due to the cellular degeneration leading to the reduction in the number of cells. Prameela (1997) reported degeneration of trophocytes in the ovary of *D. cingulatus* treated with extracts of *Chromolaena odorata* (syn. *Eupatorium odoratum*) and *Vitex negundo*. Abnormal shape and size of the follicles is apparently due to the defective orientation of the follicular cells. The follicular cells fail to surround the oocyte as an intact, continuous layer. Large vacuoles amidst the ooplasm might have resulted from ooplasmic shrinkage.

In the present study the follicle cells are abnormal and deformed. It seems that the follicle cells are not competent to take over their normal functions during vitellogenesis. Yolk is absent in the follicles. Impairment in the follicle cell differentiation and functioning remains a significant reason for arrested vitellogenesis observed in the treated insects. In the control, the interfollicular tissue and lateral trophic tissue also have active roles in the transfer of vitellogenic materials into the oocyte. Follicular epithelium, inter follicular tissue and lateral trophic tissue are atrophied or absent in all treated insects. These structural abnormalities have a cumulative role in the present results associated with arrested vitellogenesis and oocyte development in *O. rhinoceros*. Disrupted and irregular follicular epithelium, abnormal vitellogenesis and vacuolated ooplasm were observed in *Heteracris littoralis* by azadirachtin (Ghazawi *et al.*, 2007).

Thin and abnormal follicular epithelium, irregular shape of oocytes, arrested vitellogenesis and deformed ovarioles were reported in *Dysdercus cingulatus* by methanolic extract of *Chromolaena odorata* (Prameela, 1997). Structural and functional anomalies induced by the phytochemicals in the follicular epithelial cells are possibly the reason for the failure of chorion deposition.

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Distribution pattern of white fly, *Bemisia tabaci* under natural condition on okra cultivars

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ABSTRACT: Spatial distribution of *Bemisia tabaci* studied on okra cultivars showed significant differences on the density of pest at different stages of crop growth i.e. 30, 45 and 60 days after planting. The peak population was seen on 60 day old crop in 2005 and 2006, while the lowest was on 30 day old crop. Population density was higher (3.2–6.7 adult/leaf) during kharif season of 2006 than that of 2005 count (2.1–4.2 adult/leaf). *B. tabaci* followed a regular distribution while aggregated distribution pattern was also recorded when the population was low in 2005. © 2008 Association for Advancement of Entomology

KEYWORDS: Spatial distribution, *Abelmoschus esculentus*, *Bemisia tabaci*

INTRODUCTION

White fly, *Bemisia tabaci* (Gennadius) [Homoptera: Aleyrodidae] is polyphagous pest feeding on an estimated 6000 plant species and causes enormous direct damage to crops and also serves as vectors of over 100 plant viruses (Costa, 1976). It is responsible for transmission of yellow mosaic virus (YMV), which is a major constraint for cultivation of the okra crop in India (Neerja *et al.*, 2004). The distribution of insects in their habitat follows characteristic patterns depending on their inherent behaviour (Iwao, 1970) and this behaviour will affect population density estimates which constitute an essential component in insect management programmes. Present investigation was hence undertaken to understand the distribution pattern of *B. tabaci* on okra varieties.

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TABLE 1. Spatial distribution of *B. tabaci* on okra (year 2005).

Variety	Mean density per leaf			Variance (S^2)			Variance mean ratio (S^2/m)			Lloyd's Index of Mean Crowding			Lloyd's Patchiness Index (X)			Dispersion Parameter (K)			David and Moore's Index		
	30 DOC	45 DOC	60 DOC	30 DOC	45 DOC	60 DOC	30 DOC	45 DOC	60 DOC	30 DOC	45 DOC	60 DOC	30 DOC	45 DOC	60 DOC	30 DOC	45 DOC	60 DOC	30 DOC	45 DOC	60 DOC
Arka Anamica	2.768	2.734	3.430	1.077	1.987	2.254	0.389	0.726	0.657	3.080	3.320	4.015	0.779	0.726	0.900	4.531	10.00	10.000	−0.611	−0.274	−0.343
Parbhani Karanti	2.180	2.244	2.248	0.613	0.960	3.506	0.281	0.428	1.559	2.400	2.586	2.516	0.671	0.744	0.751	3.033	3.921	4.017	−0.719	−0.572	−0.559
Selection-9	2.892	2.152	2.637	0.955	0.416	0.399	0.330	0.193	2.420	3.130	2.306	2.757	0.768	0.625	0.688	4.317	2.667	3.105	−0.670	−0.807	−1.420
Seed Tech −71	2.126	2.118	3.278	0.465	0.157	1.338	0.218	0.074	0.408	2.300	2.178	3.605	0.633	0.563	0.820	2.721	2.287	5.538	−0.782	−0.926	−0.592
NBR − 1	2.184	2.120	2.508	0.287	0.337	2.006	0.131	0.159	0.799	2.290	2.247	3.148	0.603	0.604	0.921	2.514	2.520	12.529	−0.869	−0.841	−0.201
Ajeet -311 (F1)	3.740	3.508	4.016	0.570	3.030	5.098	0.152	0.864	7.269	3.860	4.198	5.032	0.774	0.942	0.933	4.422	25.63	14.905	−0.848	−0.136	−6.269
Hari Rani	3.292	2.712	2.720	1.095	0.286	2.324	0.333	0.105	0.854	1.700	2.796	3.403	0.797	0.671	0.907	4.926	3.032	10.784	−0.667	−0.895	−0.854
Depti	2.672	3.318	2.188	0.383	0.418	1.295	0.143	0.126	0.592	2.780	3.419	2.662	0.680	0.737	0.814	3.118	3.796	5.360	−0.857	−0.874	−0.592
Green Gold	3.134	3.046	4.228	0.417	2.093	2.220	0.133	0.687	0.525	3.240	5.365	4.648	0.724	0.897	0.888	3.615	9.685	8.906	−0.867	−0.313	−0.525
Ajeet-121	2.234	2.472	3.558	0.303	0.345	0.854	0.136	0.139	0.240	2.340	2.583	3.750	0.613	0.652	0.797	2.584	2.873	4.683	−0.864	−0.861	−0.240

DOC = Day Old Crop

1. When variance mean ratio is less than 1, 1 or more than 1, distribution will be regular, poisson or aggregated respectively.
2. If patchiness value is less than 1, equal, or more than 1, the distribution will be dispersed, random or clumped, respectively.
3. Higher value of exponent K indicates the greater extent of aggregation and it is a negative binomial.
4. When David and Moore's Index value is zero (0), the distribution is random, positive value is for negative binomial (aggregated) and negative for positive binomial (regular).

TABLE 2. Spatial distribution of *B. tabaci* on okra (year 2006)

Variety	Mean density per leaf			Variance (S^2)			Variance mean ratio (S^2/m)			Lloyd's Index of Mean crowding			Lloyd's patchiness index (X)			Dispersion parameter (K)			David and Moore's index		
	30 DOC	45 DOC	60 DOC	30 DOC	45 DOC	60 DOC	30 DOC	45 DOC	60 DOC	30 DOC	45 DOC	60 DOC	30 DOC	45 DOC	60 DOC	30 DOC	45 DOC	60 DOC	30 DOC	45 DOC	60 DOC
Arka Anamica	3.724	3.906	4.974	0.977	2.247	3.193	0.262	0.572	0.642	3.934	4.366	5.487	0.981	0.892	0.928	5.048	9.196	13.891	−0.738	−0.428	−0.358
Parbhani Karanti	5.378	5.198	5.412	0.432	4.393	5.627	0.080	0.845	1.039	6.085	5.870	6.240	0.829	0.971	0.993	5.847	33.56	13.820	−0.920	−0.155	−0.039
Selection-9	4.650	4.000	3.989	2.890	7.667	3.095	0.622	1.917	0.776	3.087	5.533	4.605	0.919	0.771	0.934	12.284	4.363	17.850	−0.388	−0.917	−0.226
Seed Tech – 71	3.196	3.858	6.520	1.998	5.313	0.352	0.625	1.377	0.054	4.600	4.959	6.560	0.999	0.903	0.855	8.526	10.40	6.893	−0.375	−0.377	−0.946
NBR – 1	3.526	5.182	5.148	1.783	1.800	2.667	0.506	0.347	0.518	3.390	5.459	5.560	0.879	0.874	0.906	8.280	7.939	10.681	−0.494	−0.653	−0.482
Ajeet -311 (F1)	5.130	6.438	6.716	3.525	4.560	0.667	0.687	0.708	0.108	5.679	7.004	6.790	0.939	0.955	0.866	16.397	22.06	7.459	−0.313	−0.292	−0.892
Hari Rani	3.324	4.174	5.356	1.535	6.837	3.273	0.462	1.638	0.611	4.636	5.484	5.840	0.972	0.847	0.912	6.175	6.542	11.372	−0.538	−0.638	−0.389
Depti	4.164	4.992	3.928	2.785	3.350	3.499	0.668	0.671	0.891	7.259	5.528	4.630	0.921	0.934	0.979	12.573	15.17	32.210	−0.332	−0.331	−0.109
Green Gold	3.324	5.180	4.384	1.730	0.703	5.787	0.520	0.136	1.320	3.740	5.288	5.440	0.856	0.833	0.927	6.932	5.993	13.698	−0.480	−0.864	−0.320
Ajeet-121	5.658	5.574	3.764	0.947	1.145	1.375	0.167	0.205	0.365	5.792	5.738	4.050	0.853	0.857	0.832	6.796	7.015	5.930	−0.833	−0.795	−0.635

DOC = Day Old Crop

1. When variance mean ratio is less than 1, 1 or more than 1, distribution will be regular, poisson or aggregated respectively.
2. If patchiness value is less than 1, 1 or more than 1, distribution will be dispersed, random or clumped, respectively.
3. Higher value of exponent K indicates the greater extent of aggregation and it is a negative binomial.
4. David and Moore's Index value for zero (0) a random, the distribution is random, positive value is for negative binomial (aggregated) and negative for positive binomial (regular).

MATERIALS AND METHODS

The experiments were carried out in the field of Faculty of Agricultural Sciences, Aligarh Muslim University, Aligarh, during kharif season of 2005 and 2006. Seeds of okra cultivars (vide Table 1) were sown in 3rd weak of Feb. 2005 and 2006 in 3 × 3 m plots with a row spacing of 45 cm and plant to plant spacing of 30 cm. Each variety was replicated in three plots. Standard agronomic practices were followed. Pest population on 30, 45 and 60 days old crops (DOC) were assessed. Five plants were selected at random from each plot and tagged. Counting was done in morning hours and a total of six leaves (2 leaves each from top, middle and lower position) were used for the same. The data were analyzed statistically. The spatial distribution pattern was assessed by calculating variance mean ratio (Elliot, 1977), Lloyd's index of Patchiness (Lloyd's, 1967), Lloyd's index of mean crowding (X), index of clumping of David and Moore (1954) and Dispersion parameter (k) (Katti and Gurland, 1962).

RESULTS AND DISCUSSION

The density of *B. tabaci* population on the leaves of okra plant exhibited a significant difference on crops at three different growth stages viz., 30, 45 and 60 day old crops (Table 1, 2). The peak population was observed on 60 day old crop in both years and lowest on 30 day old crop. The population density was higher (3.2–6.7 adult/leaf) during 2006 as compared to 2005 (2.1–4.2 adult/leaf). The highest population (6.72) was recorded on variety Ajeet–311 at 60 day old crop in kharif season of 2005. The variance was less than mean at all observations except some cases on 60 day old crop of 2005 (Parbhani Karanti, Ajeet-311) and 45 day (Selection-9, Hari Rani) and 60 day old crop of 2006 (Green gold), which indicated a regular distribution.

Variance mean ratio was less than 1 at all observations except some cases where regular distribution and aggregated nature was noticed on 45 day old crop during 2006 (Selection-9, Seed Tech-71, Hari Rani), 60 day (Green Gold) and 60 day old crop of 2005 (Parbhani Karanti, Selection-9 and Ajeet-121).

The patchiness index was not significantly greater than 1, which showed a regular distribution nature of *B. tabaci*. The distribution pattern of population of *B. tabaci* can be adequately explained by the exponent 'K' of the negative binomial, which is an index of aggregation of population. Southwood (1978) reported that the smaller the value of 'K', the greater the extent of aggregation. The value of 'K' in all observations was more than two (2) and this indicates that the extent of aggregation was less and the distribution approach randomness or regular dispersion. The index of clumping of David and Moore gave a value of zero for a random population and the values with negative and positive signs showed a regular and contagious pattern of insect population respectively. The observed values of David and Moore's index were lower than the random values and are having negative signs which again shows regular nature of the pest in most of observations. The value of mean crowding increased with the increase in mean adult density. Values of Lloyd's index of Patchiness were always less than 1 in the present study which further confirms the regular nature of distribution of

white fly. Sharma (2001) observed that the pest followed the regular distribution in the beginning of the infestation each year and contagious distribution during rest of the period of crop infestation. Pereira *et al.* (2004) found a positive binomial distribution of adult of *B. tabaci* biotype B in common bean, *Phaseolus vulagaris* in November and February plantings. The results of Rathore and Tiwari (1998) showed an aggregated distribution of *B. tabaci* on mung bean (*Vigna radiata* (L.) Wilczek), urd bean (*Vigna mungo* (L.) Hepper) and cowpea (*Vigna unguiculata* (L.) Walp.) during the summer and kharif seasons. They also reported that crops, cropping stage and seasons did not affect the aggregated behaviour. However, the degree of aggregation was greater when the population was high and showed a tendency towards randomness in the case of low density of *B. tabaci*. Shen *et al.* (2005) found that the number of *B. tabaci* adults was highest on the upper, tender and fully open leaves on aubergine, watermelon and musk melon and the pest was aggregated on these plants as well as on cucumber. Therefore, it can be concluded that the distribution pattern of adult population of *B. tabaci* followed regular pattern of distribution on okra crops though aggregated distribution pattern was recorded on many others.

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New reports of predatory mites (Acari: Prostigmata, Mesostigmata) from medicinal plants of Darjeeling district, West Bengal, India with description of a new species

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ABSTRACT: Eighteen species of mites under 6 families and 2 orders, recorded for the first time from 11 different species of medicinal plants of Darjeeling district of West Bengal, India, are reported in this paper. *Erythraeus cinchoni* sp. nov. is described and illustrated. © 2008 Association for Advancement of Entomology

KEYWORDS: Predatory mites, medicinal plants, new reports, *Erythraeus cinchoni* sp. nov.

INTRODUCTION

Predatory mites are of great economic importance as they are used in the biological control of economically injurious mites (Slone and Croft, 2001). A systematic survey was conducted in different medicinal plant gardens, situated at different altitudinal ranges, extending from 594 ft (Sukna) to 6000 ft. (Darjeeling Town) of Darjeeling District, West Bengal during the months of November-December, 2006. Special attention was made to collect mite specimens from the Cinchona plantations at Mungpoo at an altitude of 3,500 ft. Altogether 20 species of mites were identified from 11 different species of medicinal plants, all of which were predatory in nature except the one belonging to the genus *Tetranychus*. The present communication includes new reports of 18 species of mites belonging to 5 families and 2 orders. Besides, 5 species namely *Anystis baccarum* (Linnaeus), *Cunaxa myabunderensis* Gupta & Ghosh, *Agistemus unguiparvus* Gonzalez-Rodriguez, *Amblyseius (Amblyseius) aerialis* (Muma)

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and *Typhlodromus (Amblydromella) himalayensis* Gupta were recorded for the first time from the state of West Bengal. This paper also deals with the description and illustration of a new species of the genus *Erythraeus* Latreille (Family: Erythraeidae). Type specimens are kept in the Entomology and Wildlife Biology Research Laboratory, University of Calcutta, which in due course will be deposited in the National collection of Zoological Survey of India, Kolkata. All the measurements are given in microns. The senior author did the entire collection.

Order I. Prostigmata

Family 1. Anystidae Oudemans, 1902

1. *Anystis baccarum* (Linnaeus)

1758. *Acarus baccarum* Linnaeus, *Systema Naturae*, 10th Ed. 106.

Collection records: 1 Female, India: West Bengal, Darjeeling, Mungpoo Govt. Quinine Factory Plantation area, ex *Cinchona officinalis* Linn. dated: 21.11.2006.

Habitat (Medicinal plant): *Cinchona officinalis* (new report).

Distribution: India: Jammu & Kashmir, Punjab (Gupta, 2002); West Bengal (new report); Elsewhere: U.S.A., Juan Fernandez Island. (Close to Chile), St. Helena, Faeroes Island., Mexico, Australia, Europe, Japan, North and South Africa (Gupta, 2002).

Family 2. Cunaxidae Thor, 1902

2. *Cunaxa myabunderensis* Gupta & Ghosh

1980. *Cunaxa myabunderensis* Gupta & Ghosh, *Rec. Zool. Surv. India*, **77**: 190–192.

Collection records: 3 females, India: West Bengal, Darjeeling, 5th mile-Siliguri, ex *Zingiber* sp., dated: 23.11.2006.

Habitat (Medicinal plants): *Aegle marmelos* (Gupta, 2002), *Zingiber* sp. (new report).

Distribution: India: Andaman & Nicobar Islands. (Gupta, 2002), West Bengal (new report).

3. *Cunaxa womersleyi* Baker & Hoffmann

1948. *Cunaxa womersleyi* Baker & Hoffmann, *An. Esc. Nac. Cienc. Biol. Mexico*, **6**: 234–235.

Collection records: 2 females, India: West Bengal, Darjeeling, Sukna, ex *Ocimum sanctum* L., dated: 24.11.2006.

Habitat (Medicinal plant): *Ocimum sanctum* (new record).

Distribution: India: West Bengal; Elsewhere: U.S.A. (Gupta, 2002);

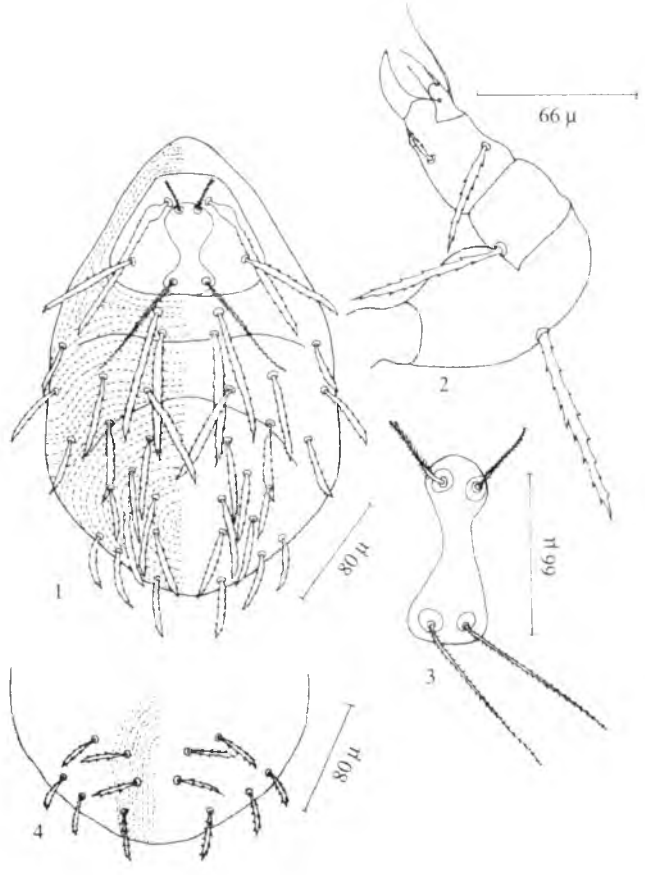

FIGURE 1. *Erythraeus cinchoni* sp. nov. (Larva): 1. Dorsal view; 2. Dorsal aspect of terminal segments of palp; 3. Crista metopica (enlarged view); 4. Venter of opisthosoma.

Family 3. Erythraeidae Robineau-Desvoidy, 1828

4. *Erythraeus cinchoni* sp. nov. (figures 1–10)

Larval diagnosis

Body oval, 495 long (from base of gnathosoma upto posterior tip of body) and 191 wide. Crista metopica 66 long and 33 wide, reaching anteriorly upto 1st pair of dorsal setae and little behind coxa II. Anterior sensillary short and 26 long, posterior sensillary 66 long. Pedipalp 165 long; tibial claw 26 long; seta on palp femur 66 long, seta on palp genu 50 long. Terminal seta on palp tarsus 43 long and the other two being 20 and 13 long respectively. Propodosomal scutum 92 long and 72 wide. Anterior dorsal propodosomal seta 116 long and posterior dorsal propodosomal seta 63 long- all being thick and serrate. Dorsal hypostomal setae 17 pairs long, thick serrate

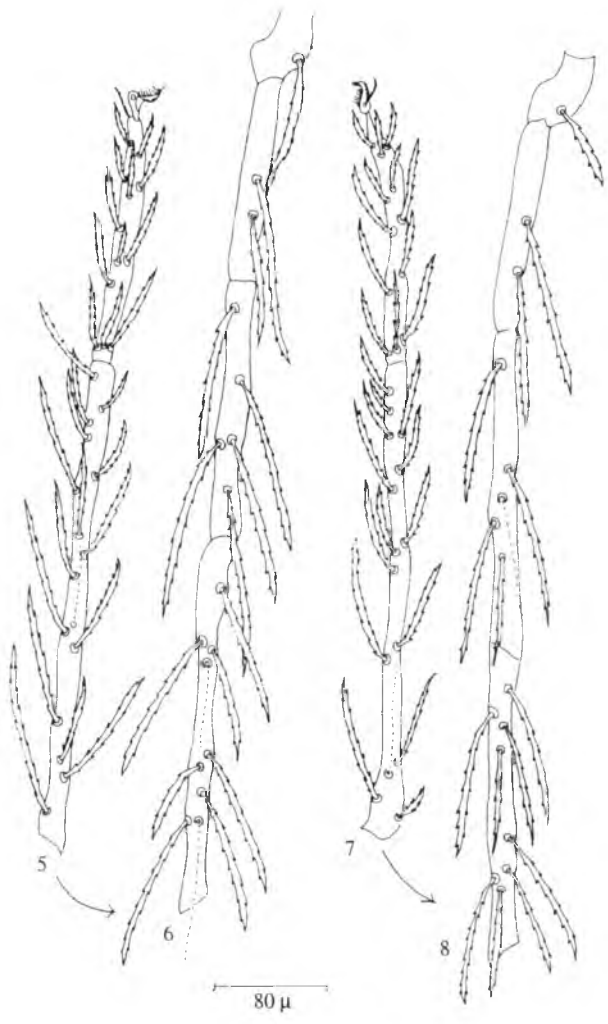

FIGURE 1. *Erythraeus cinchoni* sp. nov. (Larva): 5. Leg I- tarsus, tibia; 6. Leg I- genu, femur, Trochanter, coxa; 7. Leg II- tarsus, tibia; 8. Leg II- genu, femur, Trochanter, coxa.

and their length varies from 33–66.Ventral setae 12 pairs of which 2 pairs in mid ventral region about 20 long. Anteriorly, ventral setae of the propodosomal region less thick and less barbed. Postventral seta varies from 33–56 long. Hysterosomal striation transverse medially and oblique laterally; the posterior region striation mostly transverse. Setae of genitoanal region also long, serrate like those of dorsal region. Legs 3 pairs, being enormously long measuring Leg I 1006, Leg II 999 and Leg III 1013 long. Leg chaetotaxy as figured. All the leg setae being thick, serrate and long; tarsus terminates in a pair of claws.

FIGURE 1. *Erythraeus cinchoni* sp. nov. (Larva): 9. Leg III- tarsus, tibia; 10. Leg III- genu, femur, Trochanter, coxa.

Male: Unknown

Material examined

Holotype: Larva, India: West Bengal, Darjeeling, Mungpoo Govt. Quinine Factory plantation area, ex *Cinchona officinalis* Linn., dated: 21.11.2006, coll. Indranil Roy.

Paratypes: 3 Larvae, same data as for holotype.

Etymology: The species name is after the host plant.

Remarks

This new species is close to *Erythraeus plumosus* (Khot, 1963) but differs from the structure of crista metopica and dorsal idiosomal setae which are extremely long in case of this new species. Further it can be differentiated from *E. (Zaracarus) sibuljinicus* (Haitlinger, 2004) by nature and number of setae on dorsal surface and also by shape of crista metopica.

Family 4. Stigmaeidae Oudemans, 1931

5. *Agistemus simplex* Gonzalez-Rodriguez

1965. *Agistemus simplex* Gonzalez-Rodriguez, *Univ. Calif. Pub. Ent.*, 33–34.

Collection records: 2 females, India: West Bengal, Darjeeling, Salugara, ex *Zingiber* sp., dated: 22.11.2006.

Habitat (Medicinal plants): *Azadirachta indica,* (Ghosh and Gupta, 2003), *Zingiber* sp. (new report)

Distribution: India: West Bengal (Gupta, 2002); Elsewhere: Mexico (Gonzalez-Rodriguez, 1965).

6. *Agistemus unguiparvus* Gonzalez-Rodriguez

1965. *Agistemus unguiparvus* Gonzalez-Rodriguez, *Univ. Calif. Pub. Ent.*, 41–43.

Collection records: 3 females, India: West Bengal, Darjeeling, Sukna, ex *Aristolochia indica* L., dated: 24.11.2006.

Habitat (Medicinal plants): Citrus, cotton (Gupta, 2002), *Aristolochia indica* (new report).

Distribution: India: Uttar Pradesh, Tripura (Gupta, 2002), West Bengal (new report); Elsewhere: Mozambique (Gupta, 2002).

Family 5. Tydeidae Kramer, 1877

7. *Lorryia* sp.

Collection records: 4 females, India: West Bengal, Darjeeling, Lloyed Botanical Garden, ex *Terminalia myriocarpa* Huerk & Muell., dated: 18.11.2006.

Order II. Mesostigmata

Family 6. Phytoseiidae Berlese, 1916

8. *Amblyseius (Amblyseius) aerialis* (Muma)

1955. *Amblyseius (Amblyseius) aerialis* (Muma), *Ann. Ent. Soc. Amer.*, 48: 264–266.

Collection records: 9 females, India: West Bengal, Darjeeling, Lloyed Botanical Garden, ex *Clerodendron siphonanthus* R. Br., dated: 18.11.2006.

Habitat (Medicinal plants): *Boerhavia diffusa, Carica papaya, Citrus* sp. (Gupta, 2003, 2005). *Clerodendron siphonanthus* (new report).

Distribution: India: Arunachal Pradesh, Bihar, Karnataka (Gupta, 2003), West Bengal (new report); Elsewhere: U.S.A., Galapagos Isls., Mexico, Hondurus, Jamaica, Brazil, Algeria (Gupta, 2003).

9. *Amblyseius (Amblyseius) herbicolus* (Chant)

1959. Typhlodromus *(Amblyseius) herbicolus* Chant, *Can. Ent.*, 91: 84–85.

Collection records: 15 females, 7 males, India: West Bengal, Darjeeling, Mungpoo, Govt. Quinine Factory Plantation area, ex *Cinchona officinalis* Linn., dated: 21.11.2006.

Habitat (Medicinal plants): Guava, papaya, wood apple, *Hibiscus rosa-sinensis* (Ghosh and Gupta, 2003). *Aegle marmelos, Coccinia grandis, Ficus religiosa, Colocasia esculenta* (Lahiri *et al.*, 2004; Gupta, 2005)); *Cinchona officinalis* (new report).

Distribution: India: Arunachal Pradesh, Bihar, Tripura, West Bengal; Elsewhere: Philippines, Taiwan, Thailand, Japan, Madagascar, U.S.A., Mexico, Brazil, West Indies (Gupta, 2003).

10. *Amblyseius (Amblyseius) largoensis* (Muma)

1955. *Amblyseiopsis largoensis* Muma, *Ann. Ent. Soc. Amer.*, 48: 266.

Collection records: 8 females, India: West Bengal, Darjeeling, Sukna, ex *Aristolochia indica* L., dated: 24.11.2006.

Habitat (Medicinal plants): *Mangifera indica, Psidium guajava, Hibiscus rosa-sinensis* (Ghosh and Gupta, 2003); *Achyranthes aspera, Aegle marmelos, Anacardium occidentale, Azadirachta indica, Bauhinia purpurea. Bauhinia acuminate, Boerhavia diffusa, Carica papaya, Catharanthus roseus, Clerodendrum inerme, Coccinia grandis, Citrus spp., Curcuma aromatica, Datura metel, Ficus bengalensis, Ficus carica, Justicia adhatoda,Nerium indicum, Cassia fistula, Piper nigrum, Piper betle, Piper longum, Psidium guajava, Punica granatum, Rauvolfia tetraphylla, Ricinus*

communis, Thevetia nerifolia, Wissadula periplocifolia, (Lahiri *et al.*, 2004; Gupta, 2005); *Aristolochia indica* (new report).

Distribution: India: Himachal Pradesh, Assam, Arunachal Pradesh,Bihar, Tripura, Manipur, West Bengal, Andhra Pradesh, Karnataka, Kerala, Andaman & Nicobar Isls., Gujrat; Elsewhere: Philippines, Taiwan, Thailand, Japan, Israel, Iran, South Africa, New Zealand, U.S.A., Mexico, Brazil, West Indies (Gupta, 2003).

11. *Amblyseius (Euseius) coccineae* Gupta

1975. *Amblyseius (Euseius) coccineae* Gupta, *Indian J. Acar.*, 1: 30.

Collection records: 7 females, India: West Bengal, Darjeeling, 5th mile-Siliguri, ex *Morus alba* L., dated: 23.11.2006.

Habitat (Medicinal plants): *Mangifera indica, Cocos nucifera*, (Ghosh and Gupta, 2003), *Anacardium occidentale, Carica papaya, Citrus spp., Coccinia grandis, Terminalia arjuna* (Gupta, 2005); *Morus alba* (new report).

Distribution: India: Jammu& Kashmir, Uttar Pradesh, Bihar, Orissa, West Bengal, Meghalaya Andhra Pradesh, Karnataka, Kerala, Andaman & Nicobar Isls., Gujrat (Gupta, 2003).

12. *Amblyseius (Euseius) coccosocius* Ghai & Menon

1967. *Amblyseius (Euseius) coccosocius* Ghai & Menon. *Oriental Ins.*, 1: 67-68.

Collection records: 2 females, India: West Bengal, Darjeeling, Salugara, Siliguri, ex *Desmodium motorium* (Houtt.) Merril., dated: 22.11.2006.

Habitat (Medicinal plants): *Anacardium occidentale, Carica papaya, Citrus spp., Coccinia grandis, Terminalia arjuna* (Gupta, 2005); *Desmodium motorium* (new report).

Distribution: India: Punjab, Tripura, West Bengal, Andhra Pradesh, Pondicherry, Tamil Nadu, Kerala, Karnataka, Lakshadweep (Gupta, 2003).

13. *Amblyseius (Euseius) finlandicus* (Oudemans)

1915. *Seiulus finlandicus* Oudemans, *Ent. Ber.*, 4: 183.

Collection records: 11 females, 2males, India: West Bengal, Darjeeling, Sukna, ex *Quercus incana* R., dated: 24.11.2006.

Habitat (Medicinal plants): *Carica papaya, Clitoria ternatea, Justicia adhatoda, Psidium guajava* (Lahiri *et al.*, 2004; Gupta, 2005)); *Quercus incana* (new report).

Distribution: India: Jammu& Kashmir, Punjab, Himachal Pradesh, Uttar Pradesh, Bihar, Tripura, Mizoram, Sikkim, Meghalaya, West Bengal, Karnataka, Lakshadwip Isls.; Elsewhere: Pakistan, Europe, Canada, Mexico, U.S.A., Africa, South America, Russia, Japan, Indonesia (Gupta, 2003).

14. *Amblyseius (Euseius) pruni* Gupta

1970. *Amblyseius pruni* Gupta, *Internat. J. Acarol.*, 1(2): 40–42.

Collection records: 8 females, India: West Bengal, Darjeeling, Lloyed Botanical Garden, ex *Clematis buchananian* DC. dated: 18.11.2006.

Habitat (Medicinal plants): *Psidium guajava, Glycosmis pentaphylla* (Ghosh and Gupta, 2003); *Bauhinia acuminate, Carica papaya, Citrus spp.* (Gupta, 2005), *Clematis buchananian* (new report).

Distribution: India: Jammu& Kashmir, Punjab, Himachal Pradesh, Uttar Pradesh, Bihar, Sikkim, Assam, Tripura, Mizoram, Arunachal Pradesh, Meghalaya, West Bengal, Lakshadweep Islands. (Gupta, 2003).

15. *Amblyseius (Typhlodromips) suknaensis* Gupta

1970. *Amblyseius suknaensis* Gupta, *Oriental Ins.*, 4: 185–186.

Collection records: 21 females, 9 males, India: West Bengal, Darjeeling, Salugara, Siliguri, ex *Barleria lupulina* Lindl., dated: 22.11.2006.

Habitat (Medicinal plants): *Azadirachta indica, Citrus* spp., *Glycosmis pentaphylla* (Ghosh and Gupta, 2003); *Hibiscus abelmoschus, Abelmoschus moschatus, Catharanthus roseus, Datura metel, Piper betle* (Lahiri *et al.*, 2004; Gupta, 2005), *Barleria lupulina* (new report).

Distribution: India: Assam, West Bengal, Kerala, Andaman & Nicobar Isls. (Gupta, 2003).

16. *Indoseiulus* sp.

Collection records: 1 female, India: West Bengal, Darjeeling, Sukna, ex *Aristolochia indica* L., dated: 24.11.2006.

17. *Phytoseius (Phytoseius) maldahensis* Gupta

1992. *Phytoseius (Phytoseius) maldahensis* Gupta, In: *State Fauna Ser. 3, Fauna of West Bengal, Part 3*, p. 177.

Collection records: 4 females, India: West Bengal, Darjeeling, Salugara, Siliguri, ex *Zingiber* sp., dated: 22.11.2006.

Habitat (Medicinal plants): *Mangifera indica* (Gupta, 2003), *Zingiber* sp. (new report).

Distribution: India: West Bengal (Gupta, 2003).

18. *Typhlodromus (Amblydromella) himalayensis* Gupta

1981. *Typhlodromus himalayensis* Gupta, *Indian J. Acar.*, 5(1-2): 32–33.

Collection records: 4 females, India: West Bengal, Darjeeling, Lloyed Botanical Garden, ex *Clematis buchananiana* DC, dated: 18.11.2006.

Habitat (Medicinal plants): *Nerium* sp. (Gupta, 2003), *Clematis buchananiana* (new report).

Distribution: India: Jammu& Kashmir, Himachal Pradesh, Uttar Pradesh (Gupta, 2003), West Bengal (new report) Andaman & Nicobar Isls., Lakshadweep Isl. (Gupta, 2003).

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A new genus and new species of Chloropidae (Diptera) from India

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ABSTRACT: A new genus *Paraapallates* with type species *P. convexa*, sp. n. is described from India. © 2008 Association for Advancement of Entomology

KEYWORDS: Diptera, Chloropidae, *Paraapallates*, gen. n., *P. convexa*, sp. n., India

INTRODUCTION

Oscinellinae is the largest of the four subfamilies of Chloropidae. Flies of this subfamily are distributed in all the faunal Regions of the world. Of the 10 tribes recognized by Nartshuk (1987) under Oscinellinae, Incertellini Nartshuk (1983) is a medium sized one represented by six genera, namely *Apallates* Sabrosky, *Aphanotrigonum* Duda, *Biorbitella* Sabrosky, *Malloewia* Sabrosky, *Incertella* Sabrosky and *Meijerella* Sabrosky. Of these five genera were erected by Sabrosky (1980) and only the last two have been reported from India.

During a revisionary study of Chloropidae of India and adjacent countries, we came across a species from Kerala in Southern India that does not fit elsewhere in the classification of the family though it shows affinities to *Apallates* belonging to tribe Incertellini. The species is placed under a new genus, *Paraapallates* with type species *P. convexa*, sp. n. Both the new genus and species are described here.

Type specimens are retained in the collections of the University of Kerala and shall later be deposited in the National Collections of Zoological Survey of India, Kolkata.

Paraapallates Cherian, gen. n.

Type species: *Paraapallates convexa* Cherian, sp. n.

Small, partly yellow flies with tomentose frontal triangle, well developed body bristles, evenly distributed scutal hairs, brownish black haltere and short preapical, anteroventral spur on hind tibia.

Head: Higher than long with dark hairs and bristles; frons nearly parallel sided, wider

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at vertex than long with fairly dense, conspicuous *fr*; frontal triangle not very distinctly demarcated, apparently reaching three-fourths length of frons, finely tomentose; face deeply concave; facial carina fades off before middle of face. Antenna erect; ant_3 subreniform, wider than long; arista slender, brownish black with conspicuous pubescence. Gena about half as wide as ant_3; vibrissal corner receding; postgena reduced; parafacialia not developed. Eye large, sparsely and finely pubescent, with vertical long axis. Head bristles well developed; *ovt* longer than *ivt*; *pvt* convergent; *oc* reclinate; *orb* 4, reclinate; *if* just outside margin of frontal triangle and posteriorly a few along its margin.

Thorax: As wide as head. Scutum convex, densely tomentose, yellowish brown with three broad partly diffused brownish black longitudinal bands and evenly distributed short hairs. Pleura predominantly black; *anepst* and *anepm* tomentose and rest of the areas polished. Scutellum nearly subtriangular, wider than long with slightly convex disc which appears nearly flattened in certain angles of illumination. Thoracic bristles black, very well developed with one *h*, 1 + 2 *npl*, 1 *dc* and *pa* 1; *pa* 2 not developed; *as* much longer than scutellum; *ss* 1 more than half as long as *as*.

Wing: Hyaline with pale brown veins; costa reaching m 1+2 which ends at apex of wing; length of second costal sector more than combined length of third and fourth sectors; discal cell of *Oscinella*-type. Anal area slightly receding. Haltere brownish black.

Legs: Slender, hind tibia with short, black, preapical anteroventral spur which is shorter than diameter of tibia; femoral organ in the form of a group of short warts nearly in two rows; tibial organ long and well developed.

Abdomen: Almost as wide as thorax, finely dark tomentose with a few pale hairs. Female cerci of medium size. Male genitalia: Cerci large, widely separated, distally becoming narrow along one-third their lengths, surstylus broad and flat basally, gradually narrowing distally and ending with obtuse apex; hypandrium complete, aedeagal apodeme projecting posteriorly far above hypandrium; postgonite long and well developed.

Distribution

Oriental Region.

Gender and derivation

Masculine based on genus *Apallates* with the prefix para.

Remarks

In the development of a preapical, anteroventrally located spur on hind tibia, genera *Apallates* and *Paraapallates* show similarity. But while in the former, frontal triangle is chiefly polished black, face is weakly concave, cephalic bristles are slender and not very conspicuous, there are 7 *orb*, scutal hairs are arranged in rows, scutellum is broadly rounded and haltere is yellow, in *Paraapallates* frontal triangle is finely

but distinctly tomentose, face is deeply concave, cephalic bristles are well developed, there are only 4 *orb*, scutal hairs are uniformly distributed and not in rows, scutellum is nearly subtriangular and haltere is brownish black. Besides, there are marked differences in the male genitalia of the two genera. In the tomentose nature of frontal triangle, uniformly distributed scutal hairs, nature of wing veins and such other characters, *Paraapallates* resembles some species of *Conioscinella*. However, apart from other characters including differences in the male genitalia, in *Paraapallates* haltere is brownish black and there is a distinct preapical spur on hind tibia whereas in *Conioscinella* haltere is yellow and preapical hind tibial spur is absent.

***Paraapallates convexa* Cherian sp. n. (figures 1–5)**

Male and *Female*

Head (Fig. 1): Mostly brownish yellow, length, height and width ratio 6:7:9. Frons brownish yellow, nearly parallel sided but widening at vertex, width at point of widening at vertex 0.6 x that of head and equal to its own length, slightly sloping at sides anteriorly, ending with convex margin which does not reach anterior margin of eye and with well developed brownish black *fr* of which a pair medially just behind anterior margin more developed, partly proclinate and convergent at tips; frontal triangle not clearly demarcated, apparently appearing to reach three-fourths length of frons, finely grey tomentose; *if* in a row along margin of triangle and a few posterior ones on the triangle within its margin. Face deeply concave, finely grey tomentose; facial carina triangular between bases of antennae and reaching linearly almost middle of face whence it fades off; epistomal margin not thickened, distinctly raised. Antennae erect; basal antennal segments yellow; ant_3 subreniform, about 1.4 x as wide as long, upper half brownish black, lower half brownish yellow; arista thickened at base, gradually narrowing and becoming very slender distally, brownish black with distinct concolorous pubescence. Gena a little less than half as wide as ant_3, finely grey tomentose with a row of oral setae; vibrissal corner distinctly receding, not reaching anterior margin of eye; postgena a little reduced, concolorous with gena. Eye large, sparsely and finely pubescent, with vertical long axis. Parafacialia not developed. Palpi rather slender, cylindrical, yellow; proboscis short with deep brownish tinge. Head bristles well developed, brownish black; *ivt* shorter than *ovt*, the latter subequal to convergent *pvt*; *oc* reclinate, distally convergent; *orb* 4, very well developed, reclinate; oral vibrissa conspicuously developed.

Thorax: Scutum prominently convex, fairly densely grey tomentose, yellowish brown with three broad brownish black partly diffused longitudinal bands of which median is longitudinally faintly subdivided and each lateral one is interrupted at transverse suture and all bands posteriorly abbreviated at around level of 1 *dc*; scutal hairs short, evenly distributed, yellow; pleura as described under the genus. Scutellum (Fig. 2) subtriangular, two-thirds as long as wide with gently convex disc which appears nearly flattened in some angles of illumination, partly grey tomentose, yellowish brown with dark tinge and a few scattered yellow hairs. Thoracic bristles well developed, with

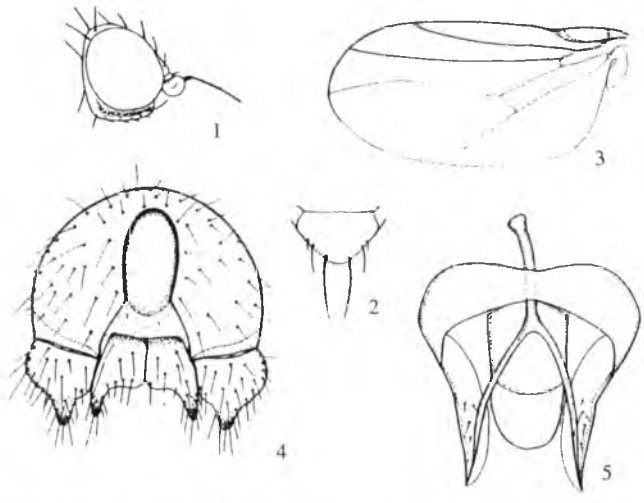

FIGURE 1. *Paraapallates convexa* Cherian, sp. n. Head; 2. Scutellum; 3. Wing; 4&5. Male genitalia.

1*h*, 1 + 2 *npl* and subequal *pa*1 and 1 *dc*; *as* 1.2 x as long as scutellum, fairly widely separated at base, becoming divergent distally; *ss* 1 about half as long as *as* and widely separated from base of *as*; ss 2, 0.4 x as long as *ss* 1.

Wing (Fig. 3): 2.3 x as long as wide, hyaline with deeply brown veins; proportions of costal sectors 2 to 4 in the ratio 17:8:6; terminal sector of r 4+5 nearly straight, that of m 1+2 conspicuously convex above medially, recalling the condition in *Conioscinella semimaculata* (Becker); discal cell a little narrowed; r-m cross vein distad of middle of discal cell, opposite 0.58 of its length; anal area slightly receding. Haltere brownish black.

Legs: Slender, brownish yellow but for slightly infuscated fore tarsi, last tarsal segment of hind leg and diffused large infuscation on midfemur, tibia and tarsi of one side and diffused dark tinge on hind femur in the holotype, and almost wholly infuscated foreleg and mid and hindfemora of one side and light infuscation on mid and hind femora on other side in the paratype. As infuscation on legs of both the holotype and paratype are not uniform and differs in legs on two sides of the same specimen, it is probable that it was partly contributed by the mode of collection and nature of preservation. Tibial and femoral organs as described under the genus; anteroventral hind tibial spur a little shorter than diameter of hind tibia.

Abdomen: Dull black, finely and darkly tomentose, fairly long with slender, pale hairs especially on distal segments. Female cerci of medium size with a few slender hairs distally. Male genitalia (Fig. 4 and 5): Cerci large, basally the two meeting in the middle, distally widely separated, becoming narrow along one-third their lengths; surstylus broad and flat basally, gradually narrowing along one-third its length

distally and ending with obtuse apex bearing long hairs especially on outer serrated margin; hypandrium complete; aedeagal apodeme projecting far above hypandrium posteriorly; postgonite well developed, gradually narrowing and becoming pointed terminally.

Length

Male: 1.5 mm; wing: 1.52 mm

Female: 1.7 mm; wing: 1.85 mm.

Holoytpe

Male, India: Tamil Nadu: Nagerkovil, 24.iii.1988, Coll. Koshey Mathew.

Paratype: 1 female, India, Tamil Nadu: Kanyakumari Dt., Kodayar, 30.iii.1988, Coll. Koshey Mathew.

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ABBREVIATIONS

anepst – anepisternum; *anepm* – anepimeron; ant_3 – third antennal segment; *as* – apical scutellar bristle; *dc* – first dorsocentral bristle; fr – frontal hair; *h* – humeral bristle; *if* – interfrontal bristle; *ivt* – inner vertical bristle ; *npl* – notopleural bristle ; *oc* – ocellar bristle ; *orb* –fronto –orbital bristle; *ovt* –outer vertical bristle; *pa*1 – first postalar bristle; pa 2 – – second postalar bristle; *pvt* – postvertical bristle; ss – subapical scutellar bristle.

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Comparative genotoxicity of alpha-cyano pyrethroids on *Drosophila melanogaster*

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ABSTRACT: The polytene chromosomes found in third instar larvae of *Drosophila melanogaster* consist of puffs in which DNA strand uncoil, protrude out as a loop and produces number of copies of mRNA and dark and light bands which contain various concentrations of DNA and proteins in the chromatin. Number of puffs and dark bands increased after intoxication with cypermethrin and alphamethrin.
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KEYWORDS: *Drosophila melanogaster*, Polytene chromosome, effect of cypermethrin, alphamethrin treatment

The salivary glands of *Drosophila melanogaster* third instar larvae have polytenized interphase chromosome and are an excellent experimental system in which puffing pattern and hence gene activity can be demonstrated (Dworniczak *et al.*, 1983). Normally during interphase the chromosome would not be visible but these polytene chromosomes consist of many duplicated strands of DNA. This structure is a type of gene amplification which allows rapid protein synthesis. The banding pattern represents areas of gene activity and inactivity.

It is well established that even very low doses of pyrethroid insecticides are able to induce marked increase in the frequency of electrical activity of insect neurosecretory cells, which may result in the release of neuro-hormones. Beside this many physiological and biochemical effects have been described in tissues outside the nervous system (Saleem *et al.*, 1998; Saleem and Shakoori, 1996, 1987). Very few reports have appeared on the genotoxicity of synthetic pyrethroids. The present study is expected to produce insight into the effect of sub-lethal doses of cypermethrin and alphamethrin on polytene chromosome of white and sepia mutants of *Drosophila melanogaster*

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TABLE 1. Polytene chromosome studies in sepia and white mutants of *Drosophila melanogaster*

Sets	Sepia mutant		White mutant	
	No. of puffs	No. of dark bands	No. of puffs	No. of dark bands
Control	7	87	17	100
Alphamethrin treated	24	140	28	142
Cypermethrin treated	21	105	21	134

Pure culture of sepia and white mutants of *Drosophila melanogaster* was maintained at Department of Zoology, SLS, Khandari, Agra. The culture was nurtured and maintained in glass culture vials of 100 ml capacity, at a temperature 25 °C, 50% relative humidity in B.O.D. incubator. The flies were fed on prescribed Drosophila food (Roberts 1986). Median Lethal concentration (LC_{50}) of the two insecticides were assessed following bioassay procedures in the laboratory and subjecting the mortality data to probit analysis (Finney 1971.) Polytene chromosome preparations were made by the conventional squash procedure using 2% aceto-carmine. All squashes with well spread polytene chromosome were processed for permanent slides which were photographed with the help of Motic Microscope system at 1000X.

Based an L.C 50 of the pesticides, cypermethrin and alphamethrin were sprayed on *D. melanogaster* flies taken in petridishes. Unsprayed lots were kept as control. At the end of 48 h after treatment flies in an all treatments (including control) were allowed to mate for five days and the experiment was conducted in F_1 generation. Third instar larvae of this generation were used for making the chromosome preparations.

The number of puffs and dark bands were found increased after treatment with α-cyano pyrethroids, cypermethrin as well as alphamethrin (Table 1, figure 1a, b and c). Therefore it could be inferred that experimental compounds not only affect nervous system, biochemistry and physiology but also genetic makeup of organism with increase in number of puffs and dark bands. DNA, RNA and protein also increased as it has already been mentioned that puffs contain mRNA and dark bands made of DNA and protein. Alphamethrin was found more potent than cypermethrin and white mutants were more susceptible than sepia mutant in the present investigation.

By correlating puffs with different physiological or developmental process, scientists have been able to locate genes on the polytene chromosome and prepare chromosome maps.

Normally gene activation in dipteran polytene chromosome is accompanied by a local decondensation of the bands and puffing. Three hundred and fifty puffed regions that have been described in *Drosophila melanogaster* salivary gland polytene chromosome to date are either light (or smooth) and relatively homogenous, or dark, with a more dense sometimes granular structure (Semestin *et al.*, 2001). Bands in such regions are decondensed incompletely, their diameters slightly exceed those of the neighbouring dense bands (Semestin *et al.*, 2001).

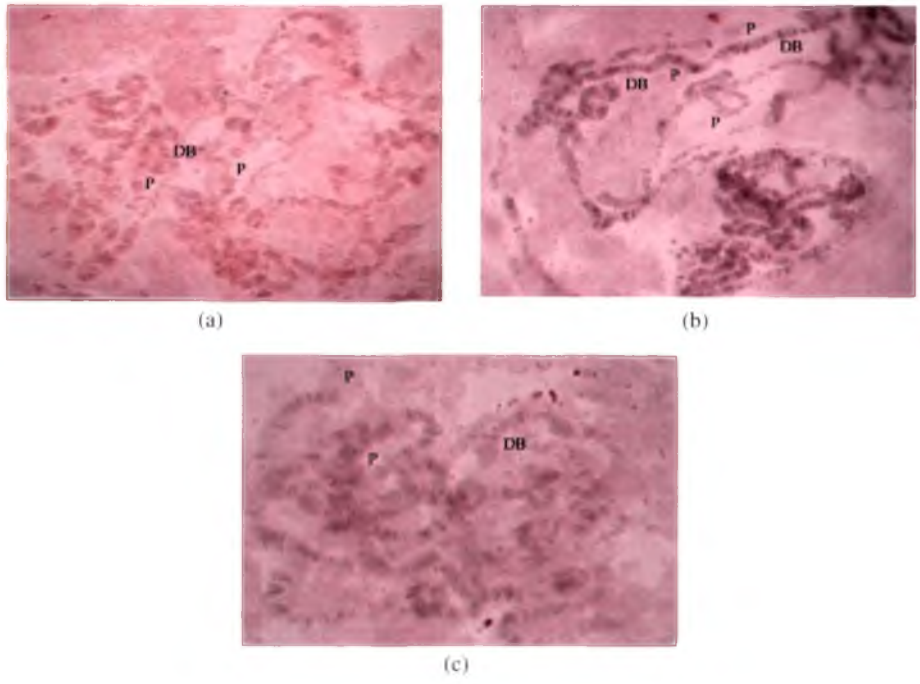

FIGURE 1. (a) Puffs (P) and dark bands (DB) in polytene chromosomes of sepia mutant of *Drosophila melanogaster* (control set) [1000X] (b) Increase in the number of puffs (P) and dark bands (DB) in polytene chromosomes of cypermethrin treated sepia mutant of *Drosophila melanogaster* [1000X] (c) Increase in the number of puffs (P) and dark bands (DB) in polytene chromosomes of alphamethrin treated sepia mutant of *Drosophila melanogaster* [1000X]

The extent of protein induction and the degree of puff induction are related to the severity of the treatment. Similar to the present findings induction in puffs within 30–40 min after incubation with caffeine that attained maximum size after 60 min in *Drosophila* melanogaster was observed (Srivastava and Bangia, 1985); hexoses as well as some disaccharides, except lactose, as efficient inducer and alcohols, such as ethanol and glycerol, showed a moderate capacity as inducers, however, mixture of galactose and glycerol was found to be significant accelerator at the puffing as well as translational level in *Chironomus thummilaria* (Cortes *et al.*, 1990) and chromosomal aberration as synapsis, ectopic pairing and chromosome break in the hydrogen peroxide treated polytene chromosome of *Chironomus samoensis* Edwards was reported (Khanna *et al.*, 2006).

White mutant flies have been found to be more susceptible to experimental compounds as compared to the sepia. This differential response may be attributed to the genetic makeup of these mutants. Toxicological and pharmacological data shows that resistance involves a modification of the affinity of the insecticide for its receptor site on the voltage dependent sodium channel (Amichot *et al.*, 1992). Genetic studies

indicate that the kdr factor is linked to the second chromosome where one sodium channel gene sch is located. Cloning and sequencing of this gene from resistance and susceptible strains revealed a single substitution that may be responsible for the loss of toxicity of insecticide in the resistant strains (Nadda *et al.*, 2005).

It could be concluded from the present investigation that alphamethrin is more potent genotoxic compound in comparison to cypermethrin. It might be because alphamethrin contains two active isomers (more than 90%) of the four cis isomers of cypermethin.

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Effect of age of the host plant on the performance of *Ceutorhynchus portulacae* Marshal (Coleoptera: Curculionidae), a herbivore of *Portulaca oleracea*

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ABSTRACT: Performance of the specialist herbivore *Ceutorhynchus portulacae* was studied in relation to age of its host plant *Portulaca oleracae*. Significant reduction in longevity and fecundity of adults were recorded in relation to age of the host plant provided. Advance in the age of the host plant was found to affect the growth, development and fecundity of the insect. The physical characteristics and chemical composition of host plant also influenced the establishment of the insect. The implications of the results in relation to biological control of purslane weed *P.oleracae* are discussed. © 2008 Association for Advancement of Entomology

KEYWORDS: *Portulaca oleracea*, *Ceutorhynchus portulacae*, biotic and functional potential, host plant phenology

Purslane weed *Portulaca oleracea* L. (Portulacaceae) ranks as one of the world's worst weeds and is of considerable importance in many agricultural crops of tropical countries (Holms *et al.*, 1977). The weevil, *Ceutorhynchus portulacae* Marshall (Coleoptera: Curculionidae) was identified as a potential natural enemy of the weed that could be effective in biological suppression of the weed (Ganga Visalakshy and Jayanth, 1995). *C. portulacae* larvae mines leaves, stem and seed capsules. Adult weevils feed on leaves, tender stems and on seed capsules. The feeding results in skeletonizing and drying up of entire plant (Ganga Visalakshy, 2007). Aim of the present study was to determine influence of host plant age on survival, growth, development, feeding preference, fecundity and longevity of larvae and adults and relate it with chemical and physical characteristics of plant.

Purslane plants were grown in pots under glass house conditions. From these 20–30 days and 45–60 days old plants were selected for study. To determine rate of oviposition bouquets of twigs of above-mentioned ages were kept separately in oviposition cage (The ovipositon cage was a plastic jar 15 × 10 cm with an aerated lid at the top.) Purslane twigs of 10 cm length were cut from plants maintained in glass house; bouquets were made by wrapping the base of twigs in wet cotton held

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together by a rubber band. The cotton swab was moistened as and when needed to prevent twigs from drying. Twenty four hour old adults were released into oviposition cage. Bouquets were replaced daily with fresh ones. Eggs laid on exposed leaves were recorded. The experiment was continued till all the exposed adults were dead. The feeding marks on the leaves exposed to the weevils for oviposition was also recorded till the adults died. The total number of feeding marks was divided by the longevity of the adults to obtain the feeding per day.

To determine effect of plant age on larval growth and survival, newly emerged larvae were placed in ventilated plastic jars as mentioned above (15 × 10 cm) containing bouquets from purslane plants of different ages. Fresh bouquets of similar age were provided as and when required. Larvae after completing development drops to the base of jar for pupation. The number of larvae that completed development, their weight and percent survival were recorded. The experiment was replicated five times with ten larvae per replication.

Concentrations of major elements in leaf samples were estimated drying them in oven at 80 °C for 72 hrs and powdering them in a wiley mill. One gram of the sample was digested using perchloric acid, nitric acid in the ratio of 9:2. Digested acid samples were used for estimating nutrient in a flame photometer/colorimeter. Concentration of nutrient is expressed on a dry matter basis. Leaf thickness was measured in cross sections under a microscope by using an ocular meter.

Plant age affected the biological parameters of *C. portulacae* larvae and adult. A greater percentage of larva survived on younger leaves (Table 1). However the development duration and weight gained by larvae in the two treatments were similar. When adults were exposed to leaves of different ages of purslane, area of leaf fed, longevity and fecundity were seen reduced in older leaves compared to younger leaves. Differences in external texture, colour, and thickness and chemical composition of the leaves of different ages were recorded. Leaves of young plants were soft to touch and light green in color, while those of older plants were dark green and hard. Similarly, younger leaves were less thick than older (Table 2). Zinc (Zn) was completely absent in younger plants while it was high in older leaves. Copper (Cu) was eight times less in older plants, while sodium was four times less in older plants (Table 2). Calcium (Ca) content was 50 per cent more in older plants than in younger plants. Potassium (P) and Manganese (Mn) concentrations were similar in leaves of different ages.

Results of the present study suggest that physical and chemical characteristics of purslane plants vary with plant age and that these changes affect growth, survival, feeding preference, fecundity and longevity of *C. portulacae* larvae and adults. The importance of physical and chemical factors for successful biocontrol programmes has been documented for alligator weed (Maddox and Rhyne, 1975), *Slavonia molest* (Taylor, 1984), *Eichhornia crassipes* (Center and Wheeler, 1991), Hydrilla (Wheeler and Center, 1996), and *Parthenium hystereophorus* (Annadurai, 1990).

TABLE 1. Effect of leaf age of purslane weed on the development of *C. portulacae*

Parameters studied	Age of the plant	
	20–30d days	45–60d old
Duration (days)	6.10	6.30
Mortality (%)	10.65*	52.00
Larval weight (g)	1.73	1.26
No. of feeding marks/day/adult	4.9*	2.5
Eggs/female/day	6.7*	1.1
Longevity (days)	69.7*	39.4

*Significant at 0.05%

TABLE 2. Effect of age on leaf thickness and concentration of major elements in leaves of *P. oleracae*

Parameters studied	Age of the plant	
	20–30d old	45–60d old
Leaf thickness (mm)	0.34	0.74
Na content (ppm)	1.30	0.30
P content (ppm)	2.03	2.03
Mn content (ppm)	59.00	52.00
Zn content (ppm)	0.00	96.00
Cu content (ppm)	120.00	15.00
Ca content (ppm)	2.43	4.01

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Butea monosperma (Lam.), a new host of *Lampides boeticus* Linnaeus in Rajastan, India

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ABSTRACT: Extensive incidence of the lycaenid butterfly *Lampides boeticus* Linnaeus was observed as a pest damaging mainly the unopened flowers and occasionally the pods and seeds of *Butea monosperma* (Lam.) Taub 'the flame of the forest' in and around Udaipur, Rajasthan, India. This is the first record of the pest on *B. monosperma*. Brief observation on the life stages of the pest is also included.
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KEYWORDS: *Lampides boeticus*, *Butea monosperma*, new host record

Lampides boeticus Linnaeus is a highly polyphagous pest attacking a wide variety of cultivated and wild varieties of legumes. Commonwealth Agricultural Bureau has recently (2004) catalogued 22 plant species as primary hosts of *L. boeticus*, seven (broom, corkwood, etc) as secondary hosts and eight as wild species. Many earlier reports on the occurrence of the pest on a variety of plants and in different countries of the world are available in literature. These include *Ulex europaeus* in New Zealand (Harding, 1971), *Crotalaria cunninghami* in Australia (Common and Waterhouse, 1981) *Medicago sativa* in Spain (Martin Cano, 1984) *Peuraria phaseoloides* in Saudi Arabia (Pittaway, 1985), *Lablab purpureus* and *Phaseolus vulgaris* in Taiwan (Chang and Chen, 1989), *Brassica* sp. (Mavi, 1992) and *Vigna exillata* in India (Govindan *et al.*, 1989).

In 2006 extensive incidence of *L. boeticus* was observed on *Butea monosperma* (Lamb) Taub, ('flame of the forest') in Gogunda block area of Udaipur district of Rajasthan. The larvae were seen entering largely in the unopened flower buds and eating from within. Sometimes they enter the pods and seeds too. Being a new host, preliminary observations on the life stages of the pest on the host was recorded in the laboratory by keeping the flower buds with insect egg in 500 ml glass jars closed with muslin cloths held in position with rubber bands. Moths lay egg singly on unopened flowers, on the flower stalk or sepals. Eggs are around 0.34 mm length, toroidal and china white in colour (figure 1). First instar larva is citrine yellow and in second and third instar the colour turns into yellowish red. All stages have a purple brown median

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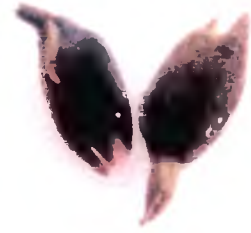
Inflorescence of *B. monosperma*



Eggs on flower buds

Larva feeding on flower

Full-grown larva

Pupa

Adult

FIGURE 1. Life stages of *Lampides boeticus* (a) Eggs on flower buds; (b) Larva feeding on flower; (c) Full-grown larva; (d) Pupa; (e) Adult.

dorsal stripe, reddish lateral streak on either side, brown head, short marginal hairs and a dense covering of minute setae on body tubercles. Pupae have pale flush colour in the begining which later becomes pale brown. The pupa has a dorsal dark line and a varying number of brownish black spots. Wings of adult males are purplish-blue on the upper side and females possess wings having dark brown colour above.

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Identification of promising multivoltine × bivoltine hybrids of the mulberry silkworm, *Bombyx mori* L.

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ABSTRACT: Thirty multivoltine × bivoltine hybrids developed through application of androgenesis at Central Sericultural Research and Training Institute, Mysore were evaluated for eleven economic characters following subordinate function index method and multiple traits evaluation index method. Two hybrids $AGL_3 \times CSR_2$ and $AGL_5 \times CSR_2$ were found promising, exhibiting significant improvement in several quantitative characters, high cumulative index value (9.7 and 10.4) and average evaluation index value (65.25 and 68.52). They are recommended for large scale evaluation by the farmers. © 2008 Association for Advancement of Entomology

KEYWORDS: *Bombyx mori*, multivoltine × bivoltine hybrids, multiple traits evaluation index, subordinate function index

Superiority of silkworm breeds and hybrids is judged on the basis of cumulative effect of several characters (Narayanaswamy *et al.*, 2002). In the mulberry silkworm, *Bombyx mori* L., the multiple traits evaluation index method of Mano *et al.* (1993) and subordinate function index method of Gower (1971) have been employed simultaneously for the identification of promising silkworm hybrids (Ramesh Babu *et al.*, 2002; Rao *et al.*, 2001, 2004, 2006; Lakshmi and Chandrashekharaiah, 2007). In the present study, an attempt has been made to identify promising multivoltine × bivoltine hybrids developed utilizing androgenesis coupled with conventional breeding techniques.

In the present study, thirty multivoltine × bivoltine hybrids were prepared utilizing six multivoltine breeds *viz.*, AGL_1, AGL_2, AGL3, AGL_4, AGL_5 and Pure Mysore (PM) and five bivoltine breeds *viz.*, CSR_2, CSR_3, CSR_4, CSR_{12} and NB_4D_2. Three replications were reared for each hybrid and 250 larvae were retained after third moult in each replication. The performance of ten top ranking hybrids along with control ($PM \times CSR_2$) is presented in Table 1.

Data presented in Table 1 show significant variation for various characters among the different hybrids. Two hybrids namely, $AGL_3 \times CSR_2$ and $AGL_5 \times CSR_2$ exhibited

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TABLE 1. Performance of selected multivoltine × bivoltine hybrids

Hybrids	Fecundity (No.)	Hatching (%)	Pupation Rate (%)	Yield/10,000 wt. (kg)	Cocoon wt (g)	Cocoon shell wt (g)	Cocoon shell (%)	Filament length (m)	Reel-ability (%)	Raw silk (%)	Neat-ness (p)	Cumulative index	Average Evaluation Index
$AGL_5 \times CSR_2$	499	96.0	97.20	19.69	2.041	0.438	21.44	885	84.33	15.53	90.7	10.40	68.52
$AGL_3 \times CSR_2$	493	96.2	96.60	18.32	1.928	0.412	21.38	870	82.33	16.17	90.7	9.79	65.25
$AGL_2 \times CSR_{12}$	473	94.6	97.33	16.97	1.775	0.377	21.22	808	79.00	15.10	89.7	7.47	56.18
$AGL_4 \times CSR_2$	427	96.9	97.60	16.98	1.782	0.365	20.50	808	80.00	14.33	90.0	7.44	56.03
$AGL_2 \times CSR_4$	484	96.3	94.80	16.43	1.756	0.359	20.46	814	81.33	14.47	90.3	7.43	49.07
$AGL_3 \times CSR_3$	490	95.4	97.47	16.86	1.764	0.364	20.62	766	79.33	15.40	88.3	7.30	50.16
$AGL_2 \times CSR_2$	487	95.3	97.73	17.04	1.782	0.369	20.70	781	78.33	16.60	89.3	7.29	55.45
$AGL_5 \times CSR_{12}$	431	95.5	96.27	16.60	1.749	0.367	21.01	786	80.00	15.70	89.7	7.27	55.23
$AGL_1 \times CSR_2$	506	94.0	95.20	17.42	1.866	0.371	19.88	811	79.00	14.90	89.7	7.15	55.24
$AGL_2 \times CSR_3$	460	96.6	97.73	16.84	1.755	0.354	20.15	727	79.00	14.63	89.7	7.05	54.21
$PM \times CSR_2$ (Control)	422	94.5	97.60	16.92	1.762	0.336	19.05	778	80.67	13.73	87.0	5.47	48.88
CD @ 5 %	22	1.4	–	0.52	0.055	0.013	0.50	50	–	1.00	1.1	–	–
CD @ 1 %	29	1.9	–	0.71	0.075	0.018	0.67	68	–	1.36	1.5	–	–

significantly higher values for most of the economic characters. It was interesting to note that all the ten top ranking hybrids have shown significantly higher values for three characters namely, cocoon shell weight, cocoon shell percentage and neatness. The cumulative index was highest in $AGL_5 \times CSR_2$ (10.4) and it was closely followed by $AGL_3 \times CSR_2$ (9.7). Hybrids with average evaluation index value above 50 can be considered to possess greater economic value. The hybrid $AGL_5 \times CSR_2$ exhibited maximum average evaluation index (68.52) followed by $AGL_3 \times CSR_2$ (65.25).

Data revealed distinctive superiority of two hybrids $AGL_3 \times CSR_2$ and $AGL_5 \times CSR_2$. No hybrid excelled in all the characters under study. Therefore, it is necessary to adopt reliable statistical methods for identification of promising hybrids giving weightage to different economic characters. In this direction, efforts have been made to identify promising silkworm hybrids utilizing multiple traits evaluation indices (Ramesh Babu *et al.*, 2002; Rao *et al.*, 2001, 2004; Lakshmi and Chandrashekharaiah, 2007). Hence in the present study, the indices obtained from the multiple traits evaluation method and subordinate function index were used and the two hybrids $AGL_5 \times CSR_2$ and $AGL_3 \times CSR_2$ were selected for field testing.

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Effect of feeding larvae of *Helicoverpa armigera* (Hubner) on Chickpea (*Cicer arietinum* L.) treated with chemical and organic fertilizers

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ABSTRACT: A field experiment was conducted to assess the effect of organic and chemical fertilizers used in cultivating chickpea (*Cicer arietinum* L.) on its major pest *Helicoverpa armigera* (Hubner).The sixth instar larvae were fed in the laboratory with leaves of the plants raised in the field experiment laid out in the research centre of the Narendra Dev University, Faizabad. The results showed that the application of NPK and farm yard manure increased the length and protein content of the larvae significantly when compared to the treatments with vermicompost as well as rhizobium for seed dressing and control. The weight of the larvae, and essential as well as non-essential aminoacid content of the larvae did not vary significantly from control. Rhizobium treated plants caused exceptionally low levels of free amino acids in the larvae. Significant differences were not seen in the effects of NPK and farm yard manure application. © 2008 Association for Advancement of Entomology

KEYWORDS: *Helicoverpa armigera*, effect of chemical/organic fertilizers, *Cicer arietinum*

Application of nitrogenous fertilizers in chickpea had been reported to enhance the development of larva and pupa of *Helicoverpa armigera* L., a regular pest on this crop. Viswanath (2005) observed that organic crops show higher tolerance to insect pests due to thicker cell wall and lower levels of free amino acids in the plants. Pest control through host nutrition manipulations has become a promising approach in recent IPM strategies (Giri *et al.*, 2004; Geire, 1986). In this context the effect of rearing larvae of *H. armigera* on chickpea grown under field conditions in Faizabad, giving chemical and organic fertilizers, was studied in the laboratory at Narendra Deva University of Agriculture and Technology, Faizabad U.P., India. The results are reported in this paper.

The field experiment was laid out adopting a completely randomized block design with a plot size of 3 × 2 m. Udai variety of Chickpea (*C. arietinum*) was sown in the plots with the following fertilizer treatments applied as basal dose: (1) NPK @ 20:60:40 kg/ha, (2) Farm yard manure @ 8 t/ha, (3) vermicompost @ 37.5 q/ha,

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(4) seed inoculation with *Rhizobium* culture @ 20mg/kg seed, and (5) control without any fertilizers.

H. armigera was reared in the laboratory using chick pea leaves collected from field. Leaves from the field experiment were collected plot wise and brought to the laboratory. Leaves from each plot were transferred to adequate number of Petri dishes (9 cm dia). First instar larvae of *H. armigera*, collected from the lab culture were individually transferred to the Petri dish. The larva in each dish was continuously supplied with leaves collected from the same plot. Adequate replications were maintained for each treatment. When the larvae reached sixth instar stage they were collected separately from each replication and their length was measured under a microscope. The weight of each larva was assessed using an electronic balance. Protein content of larva in each treatment was estimated following the methods of Lowry *et al.* (1951). Free amino acids and amides were estimated following the methods of Consden *et al.* (1944), Patridge (1948) and Bates *et al.* (1973). The data collected were subjected to statistical analysis and the results are presented in Table 1.

The data showed that the least length of the larva was in control (26.35 mm) and the highest length was in NPK treatment (29.90 mm) and the latter came on par with FYM (28.60 mm). The lengths of larvae in treatments with vermicompost (27.20 mm) and *Rhizobium* (27.60) were on par and significantly lower than those in FYM, but higher than that of control. Regarding the mean weights of the larvae in different treatments vermicompost treatment gave rise to larvae weighing significantly less (0.188 g) than the larvae in control (0.237 g) while the weight of larvae in remaining treatments (0.218 to 0.257 g) were on par with that of control.

Among the biochemical components of *H. armigera* larvae, protein content was seen significantly higher and on par with NPK, FYM and *Rhizobium* treatments (2427, 2240 and 2461 μg/100 mg tissue) than in treatments with vermicompost and control, the latter two also being on par.

Seven essential aminoacids, leucine, isoleucine, valine, lysine, histidine, arginine, threonine, were identified in NPK, FYM and *Rhizobium* treatments and they are on par on weight basis. Of the above amino acids, lysine and histidine were lacking in vermicompost treatment while arginine and threonine were absent in control. The content of essential aminoacids was significantly higher in FYM and was very low in *Rhizobium* treatment compared to control. The remaining treatments were on par among themselves and also with control.

Results thus showed that the lengths of the larvae fed with leaves collected from chickpea plants treated with chemical fertilizers and farm yard manure were significantly higher than those obtained in other treatments. Vermicompost and rhizobium treatments also produced larvae longer than those in control and those treatments were on par but significantly less than NPK & FYM. With reference to the larval weight all the treatments came on par with control except vermicompost in which the larval weight was only 79% of the larval weight in control. Zing *et al.* (1982) observed that the application of nitrogen fertilizers in cotton plants caused an increase in the weight of *H. armigera* larvae. Purohit and Deshpande (1991) observed

TABLE 1. Effect of host nutrition on the length, weight, protein and amino acid content of sixth instar larvae of *H. armigera*.

Treatments	Length (mm)	Weight (gm)	Protein (μg/100 mg fresh weight	Amino acids μg/100 mg fresh weight																			
				Essential							Non essential												
				Leu & Iso leuc	Valine	Lys & Hist	Arginine	Threonine	Total wt	Total Nos	α Alanine	Glycine & Serine	Glut amic acid	Asp artic acid	Glut amine	γ Amino butyric	β alanine	Tyrosine	Aspara-gines	Cystine	Proline	Total wt.	Total Nos
NPK	29.90	0.257	2426	98.31	44.24	22.47	11.93	29.49	206.44	7.0	64..6	13.34	–	9.83	17.55	23.17	–	44.94	7.02	6.32	2.70	189.47	10
FYM	28.60	0.235	2240	100.00	61.66	114.16	17.50	28.33	321.65	7.0	67.5	71.66	–	17.5	30.83	7.50	–	21.66	10.0	3.30	6.67	236.62	10
Vermi-compost	27.20	0.188	1527	89.70	86.0	–	19.11	19.11	213.94	5.0	75.0	13.97	–	12.5	22.0	–	47.05	35.29	–	66.17	8.12	280.10	9
Rhizobium culture	27.60	0.218	2461	12.16	6.25	10.78	13.05	7.19	49.43	7.0	5.91	–	7.74	3.87	–	–	–	2.26	0.60	1.54	13.54	35.37	7
Control	26.75	0.237	1385	76.12	56.08	96.15	–	–	228.35	5.0	55.28	41.40	–	17.6	20.03	41.66	28.84	44..07	–	–	5.78	254.68	9
CD at 5%	0.40	0.023	325.04	10.4	5.3	6.9	1.32	2.13	24.1	0.71	7.49	3.93	0.22	1.89	2.46	2.07	1.87	3.14	0.42	1.88	0.91	25.37	1.09

that the addition of nitrogenous fertilizers in host plants enhanced the food intake and consequently the larval weight. With reference to the length, the larvae of *H. armigera* in NPK and FYM treatment came on par and higher with consequent reduction in the tolerance/resistance in host plants. Advantage of using organic fertilizers over NPK (Viswanath, 2005) was not evident in the data of the experiment. The variation between the results of this experiment and earlier reports may be attributed to the soil plant interaction, or plant environment interaction in the field situations in Faizabad.

Protein content of the insects grown on hosts treated with NPK and FYM came on par and significantly higher than in control but it came on par with rhizobium treatment also, a treatment which did not cause higher growth of the larvae. Highest numbers of essential and non-essential amino acids were detected in NPK and FYM treatments as well as rhizobium treatments. But on the basis of the weight of the amino acids all the treatments came on par with control except rhizobium in which a very low content was observed. Thus the findings did not agree with the earlier reports that fertilizer application increases the weight (Purohit and Deshpande, 1991; Zing *et al.*, 1982) protein (Haunerland *et al.*, 1990) and free amino acids (Hedge, 2005). Adverse effects of inorganic fertilizers on the pest (Viswanath, 2005) also was not evident in the results of this experiment since FYM and NPK came on par throughout. The weight of essential and non-essential aminoacids observed in rhizobim treatment compared to control, was remarkably low and it may be attributed to some inhibitory effects. Lower length of the larvae in vermicompost and rhizobium treatments can also be attributed partly to the absence of some essential aminoacids in the treatments as observed by Chapman (1998) and Singh and Singh (2007).

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A new host plant record for *Oberea artocarpi* Gardner (Coleoptera: Cerambycidae)

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ABSTRACT: *Ficus callosa* Willd. (Moraceae) is reported as a new host plant of *Oberea artocarpi* Gardner (Coleoptera: Cerambycidae). © 2008 Association for Advancement of Entomology

KEYWORDS: Host plant, *Ficus callosa*, *Oberea artocarpi*, Kerala, India

The long horn beetle *Oberea artocarpi* Gardner is a minor pest of mulberry in south India. Its univoltine life cycle and nature of damage on mulberry were reported from Kerala (Prathapan 1995). The known host plants of *O. artocarpi* are *Artocarpus heterophyllus* Lam. (= *A. integrifolia* L.) (Gardner, 1941; Bhasin and Roonwal, 1954; Duffy, 1968) and *Morus alba* L. (Prathapan, 1995) (both Moraceae).

Infestation of *O. artocarpi* on young plants of *Ficus callosa* Willd. (Moraceae) was observed in a homestead at Koothattukulam, Kerala during 2007. Girdling of actively growing branches of about 8–9 mm diameter followed by die-back with ventilation holes is the typical symptom of infestation. An infested branch was collected on 6 November, 2007 and kept in the laboratory at College of Agriculture, Vellayani. Adult emerged on 25 March, 2008 through an oval exit hole of about 4.7 mm length and 4.0 mm width. Emergence of the adult coincided with the heavy pre-monsoon showers. *F. callosa* is a fast growing soft wood tree of little economic importance, except that its wood is used in the match industry. *O. artocarpi* appears to be specific to Moraceae utilizing different genera of the family as its host plants. This is the first report of *O. artocarpi* on *F. callosa*. The plant vouchers are deposited in the Calicut University Herbarium (Accession Nos 6323, 6324) and the insect specimen will be deposited in the National Pusa Collection, Division of Entomology, Indian Agricultural Research Institute, New Delhi.

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F. callosa was identified by Dr A. K. Pradeep, Calicut University Herbarium.

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